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EAST LANSING

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THE QUARTERLY BULLETIN

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THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

C. M. HARDIN, DIRECTOR
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UTILIZATION OF PHOSPHATE FERTILIZER BY SEVERAL CROPS USING RADIOACTIVE PHOSPHORUS[1]

By K. LAWTON, A. E. ERICKSON, and E. LEMON
DEPARTMENT OF SOIL SCIENCE

THE CHEMISTRY OF PHOSPHORUS in soils is complex, and the most characteristic reaction of phosphate fertilizers with soil is the reversion or fixation of a large proportion of the soluble phosphorus to forms which are only slowly available to plants. This means that the utilization of soil-applied phosphate fertilizer is considerably lower than for nitrogen or potassium fertilizers applied in the same manner.

In view of this fact, a large number of investigations have been conducted in Michigan and other states in the past 25 years with phosphate fertilizers to determine their most effective rate and placement for different crops. In those studies, effectiveness has been almost entirely measured by yield response.

Until recently the actual utilization of applied phosphate fertilizer by crops could not be determined. Now that radioactive isotopes are available such a measurement can be made. Considerable work is being conducted by various agricultural experiment stations using radioactive phosphorus as a tracer in agronomic field and greenhouse investigations. Most of these studies involve the use of different tagged phosphate fertilizers in rate and placement experiments with different soils and crops.

This greenhouse study was conducted to study the utilization of phosphorus from two phosphatic fertilizers by three crop plants grown on some widespread Michigan soils. Tracer techniques were used to determine the accumulation of fertilizer phosphorus in the crops and also the quantity distribution in several soil phosphorus fractions.

[1]Fertilizer materials were prepared by the Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Dept. of Agriculture, Beltsville, Md.

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EXPERIMENTAL PLAN

Surface samples from six soil types, including Plainfield loamy sand, Fox sandy loam, Conover sandy loam, Miami sandy loam, Hillsdale loam, and Brookston loam were used in this study. Some of the more important chemical and physical properties of these soils, which are arranged from coarse to fine texture, are shown in Table 1. Radioactive

TABLE 1—Chemical and physical properties of soils

Soil type	pH	Sand, *percent*	Silt, *percent*	Clay *percent*	Moisture equivalent *percent*	Adsorbed P in soil, p.p.m.	Acid-soluble + adsorbed P in soil, p.p.m.
Plainfield loamy sand	5.4	78	14	8	5.1	46	59
Fox sandy loam.....	6.2	73	16	11	10.2	58	84
Conover sandy loam.	6.5	66	22	12	12.6	13	25
Miami sandy loam..	5.3	53	29	18	15.5	5	7
Hillsdale loam.....	6.6	49	34	17	11.8	74	178
Brookston loam.....	7.4	46	30	24	21.5	5	35

calcium metaphosphate and superphosphate fertilizers, applied at the rate of 200 pounds of P_2O_5 per acre, were thoroughly mixed with soil in one-gallon tinned cans. The nitrogen and potassium requirements of the various crops were supplied by non-radioactive fertilizer carriers. Three phosphate-responsive crops—tomatoes, wheat, and red clover, using four replications—were planted in the third week of May. Two replicates selected at random were harvested after 1 month and the remaining replicates after a 2-month period. Radioactivity and chemical measurements for phosphorus were made on the crop plants. At the time of the first harvest, soil samples were collected to study the concentration of fertilizer phosphorus in two chemically combined forms, both of which are considered by Bray[2] to be measures of phosphorus available to field crops.

RESULTS AND DISCUSSION

The dry weight yields of the several crops harvested at two dates are given in Table 2. In general, all three crops grown on the Miami,

[2]Bray, R., and Kurtz, T. 1945. Determination of total, organic, and available forms of phosphorus in soils. Soil Science 59:39-45.

TABLE 2—Effect of phosphate fertilizers on the yield of several crops

Fertilizer treatment	Dry weight of crop* at two harvest dates, gm.†					
	Tomato		Red clover		Wheat	
	1 mo.	2 mo.	1 mo.	2 mo.	1 mo.	2 mo.
	Plainfield loamy sand					
Check	0.4	3.4	0.6	3.1	2.9	6.3
Calcium metaphosphate	1.4	6.6	1.1	4.9	5.6	8.6
Superphosphate	1.2	18.2	1.5	4.6	4.5	8.7
	Fox sandy loam					
Check	2.7	26.1	1.7	5.9	5.9	8.9
Calcium metaphosphate	3.2	30.2	1.6	7.4	6.0	9.1
Superphosphate	2.8	28.4	1.7	6.7	7.0	8.6
	Conover sandy loam					
Check	0.3	2.8	0.8	3.5	1.1	3.7
Calcium metaphosphate	1.7	18.5	1.4	6.5	4.3	9.2
Superphosphate	2.0	18.3	2.0	6.7	5.9	6.8
	Miami sandy loam					
Check	0.2	0.9	0.3	1.0	1.3	2.3
Calcium metaphosphate	1.3	4.1	1.1	6.2	6.0	7.4
Superphosphate	2.2	13.2	1.2	6.6	5.6	7.9
	Hillsdale loam					
Check	4.7	29.1	2.3	9.2	6.8	9.9
Calcium metaphosphate	4.5	29.0	2.9	10.7	7.9	10.4
Superphosphate	3.8	31.6	2.8	8.1	9.1	10.0
	Brookston loam					
Check	0.5	1.1	0.9	3.8	1.8	2.9
Calcium metaphosphate	1.7	18.5	1.8	6.8	5.3	7.1
Superphosphate	2.0	18.3	2.0	6.7	5.9	6.8

*Above-ground part of crops.
†Average of two replicates.

Conover, and Brookston soils gave striking increases in yield when treated with either kind of phosphate fertilizer. Tomato plants grown on the Plainfield soil responded markedly to the phosphate applications, but red clover and wheat did not. In contrast, the use of phosphate fertilizer on Fox and Hillsdale soils was of no value in increasing the dry weights of any crop.

It is relatively easy to interpret these results in terms of the available phosphorus contents of the six soils as listed in Table 1. The Miami soil tested lowest in phosphorus, followed by Brookston, Conover, Plainfield and Fox soils. The highest available soil phosphorus value was obtained from the Hillsdale soil.

A comparison of the effect of calcium metaphosphate and superphosphate on the growth of the three crops shows both fertilizers to be satisfactory sources of phosphorus, except for tomatoes. On two soils, namely the strongly acid Plainfield and Miami samples, superphosphate gave superior results with tomatoes when compared with the metaphosphate. In contrast to superphosphate, calcium metaphosphate contains very little water-soluble phosphorus. However, this less soluble phosphate is known to release phosphorus relatively rapidly in acid soils. It is possible that the greater amount of soluble calcium that would be furnished by superphosphate is largely responsible for the difference in tomato growth from the use of these two fertilizers on the Plainfield and Miami soils. On the alkaline Brookston soil, the two phosphate carriers gave equally good results on all crops. Figures 1 and 2 show the great difference in response of toma-

A B C D

Fig. 1. The effect of phosphate fertilizer on the growth of tomato plants on a Brookston loam soil.

Treatments, left to right: a) Check, b) 100 pounds P_2O_5 per acre (superphosphate), c) 100 pounds P_2O_5 per acre (calcium-metaphosphate) and d) 200 pounds P_2O_5 per acre (superphosphate).

A B C D

Fig. 2. The effect of several phosphate fertilizers on the growth of tomato plants on a Hillsdale loam soil.

Treatments left to right: a) Check, b) 100 pounds P_2O_5 per acre (superphosphate), c) 100 pounds P_2O_5 per acre (calcium-metaphosphate) and d) 200 pounds P_2O_5 per acre (superphosphate).

toes to phosphate fertilizer on the Brookston and Hillsdale soils, respectively.

Factors which determine the use of a phosphate fertilizer, other than cost and convenience of application, are its effect on yield and quality and its efficiency of utilization by plants. In Tables 3 and 4 are given the relationships between total plant phosphorus, percentage of phosphorus in the plant derived from the fertilizer and the percentage recovery of applied fertilizer for tomatoes and red clover.

The percentage of total phosphorus in these crops is not a reliable measure of either the supply of available phosphorus in soil or the weight of dry plant material. On the other hand, the percentage of phosphorus in the crop from the fertilizer can be closely related to the original soil content of available phosphorus. The Miami, Conover and Brookston soils, which gave rather low values for available phosphorus and high yield response, produced crops having large percentage of phosphorus derived from fertilizer. In contrast, crops grown on the Hillsdale loam, highest of the soils in available phosphorus, had a relatively low fertilizer phosphorus percentage.

TABLE 3—Relationships between soil type, kind of phosphate fertilizer, and percentage of fertilizer phosphorus in the tomato plant at final harvest

Soil type	Total plant P in dry plants, percent			Plant P derived from fertilizer, percent		Recovery of fertilizer P applied, percent	
	Ck	Ca—Meta*	Super†	Ca—Meta	Super	Ca—Meta	Super
Plainfield.....	0.31	0.17	0.23	43.1	42.9	2.7	10.2
Fox.....	0.32	0.35	0.31	20.1	29.2	12.2	14.7
Conover.....	0.13	0.16	0.27	70.2	65.0	11.9	18.4
Miami.....	0.30	0.28	0.23	50.3	51.0	3.3	8.9
Hillsdale.....	0.34	0.34	0.32	16.0	18.7	9.0	10.8
Brookston....	0.13	0.22	0.23	66.5	70.6	15.4	17.0

*Ca-Meta refers to calcium metaphosphate.
†Super refers to superphosphate.

As for tomatoes, there is little difference in the percentage of fertilizer-derived phosphorus in the plants from either type of phosphate carrier. However, similar values in red clover are more variable. In Table 4 the data show that in four of the six soils a distinctly higher percentage of fertilizer phosphorus was found in clover receiving metaphosphate than superphosphate.

TABLE 4—Relationships between soil type, type of phosphate fertilizer, soil, and percentage of fertilizer phosphorus in red clover at final harvest

Soil type	Total P, percent			Plant P derived from fertilizer, percent		Recovery of fertilizer P applied, percent	
	Ck	Ca—Meta*	Super†	Ca—Meta	Super	Ca—Meta	Super
Plainfield.....	0.11	0.21	0.21	59.7	64.8	3.5	3.6
Fox.....	0.17	0.13	0.20	48.4	30.7	2.6	2.3
Conover.....	0.12	0.19	0.18	72.3	66.5	5.1	4.6
Miami.....	0.22	0.19	0.18	83.6	70.7	5.7	4.8
Hillsdale.....	0.23	0.23	0.22	33.4	44.8	4.6	4.9
Brookston....	0.19	0.19	0.16	98.3	89.4	7.3	5.4

*Ca-Meta refers to calcium metaphosphate.
†Super refers to superphosphate.

Figures for the percent recovery of the fertilizer phosphorus by tomatoes and red clover in Tables 3 and 4 show some interesting differences between soils and fertilizers. The tomato plants absorbed

roughly two to three times as much fertilizer phosphorus as the clover crop and the differences in recovery from the two fertilizer sources was also greater with the tomatoes. Total recovery is a product of yield $\times$ percentage total plant phosphorus $\times$ percentage of plant phosphorus derived from fertilizer. Since these factors do not vary directly, no clear relationship exists between the recovery values and the percentage of fertilizer phosphorus in the crop.

Approximately 30 days after the first sampling of the red clover, soil samples were taken and chemical analyses made for two fractions of available soil phosphorus. The distribution of native and fertilizer phosphorus as measured by the activity of the extracted solutions is given in Table 5 for each soil. As noted in Table 1, the values for available phosphorus in the original samples of the Plainfield, Fox, and Hillsdale soils were high. When the check and fertilized treatments are compared after fertilization and cropping, these values increased about 3 to 5 p. p. m. phosphorus in the soil extract in both the adsorbed and adsorbed plus acid-soluble fractions. A similar increase of 1 to 4 p. p. m. phosphorus was found in fertilized and cropped clover soils of the Miami, Conover, and Brookston series. As for those soils that were high in native phosphorus, only 13 to 27 percent of the extracted phosphorus of either fraction came from the fertilizer, whereas 28 to 96 percent was derived from fertilizer phosphorus applied to those soils relatively low in available phosphorus.

In general, there is a distinctly higher percentage of fertilizer phosphorus in extracts from soils treated with superphosphate than from those where calcium metaphosphate was used. This is more evident when an acid is used in the extracting solution as in the case of the acid-soluble plus adsorbed phosphorus fraction. Since calcium metaphosphate is considerably less soluble in weak acids than superphosphate, such results might be expected. However, with the exception of the Conover and Brookston soils, there appears to be no great difference in the percentage of fertilizer phosphorus between the two soil phosphorus fractions for any given soil and fertilizer. This means that the fertilizer phosphorus was distributed about equally between the two chemical forms. Since adsorbed phosphorus was removed in both tests most of the extractable fertilizer phosphorus can be considered to be in the adsorbed form.

TABLE 5—Relationships between fertilizer treatment and two phosphorus fractions extracted from soils during cropping by red clover

Fertilizer treatment	Adsorbed phosphorus		Acid—soluble + adsorbed phosphorus	
	P in soil extract, in p.p.m.	P from fertilizer, percent	P in soil extract, in p.p.m.	P from fertilizer, percent
	Plainfield loamy sand			
Check	6.5	0	8.4	0
Calcium metaphosphate	9.4	26	11.3	19
Superphosphate	9.3	25	11.8	27
	Fox sandy loam			
Check	7.8	0	10.1	0
Calcium metaphosphate	10.9	13	14.6	13
Superphosphate	10.0	18	14.6	17
	Conover sandy loam			
Check	1.2	0	5.5	0
Calcium metaphosphate	2.2	52	5.6	28
Superphosphate	4.2	36	8.0	40
	Miami sandy loam			
Check	1.1	0	1.4	0
Calcium metaphosphate	3.0	57	3.9	44
Superphosphate	3.5	60	5.4	76
	Hillsdale loam			
Check	9.6	0	15.6	0
Calcium metaphosphate	12.0	12	20.9	11
Superphosphate	14.3	23	19.4	17
	Brookston loam			
Check	0.7	0	5.5	0
Calcium metaphosphate	1.8	56	9.0	22
Superphosphate	2.5	96	8.3	46

SUMMARY AND CONCLUSIONS

Considerable variation was found in the dry weights of three crops, tomatoes, red clover, and wheat grown in the greenhouse on six Michigan soils receiving no phosphate. Differences in growth were found to be closely related to soil test values for available phosphorus. Fertilization of the soils with phosphate increased the yield of dry plant

material on three soils from 2 to 16 times over the non-phosphated treatment.

Phosphate carriers, calcium metaphosphate and superphosphate, applied at an equivalent rate of P_2O_5, were about equally effective in improving crop growth on soils in need of phosphorus except for tomatoes on Plainfield and Miami soils.

The percentage of total phosphorus in the crops studied was not an indication of either the content of available soil phosphorus or the dry plant weights.

Radioactive tracer techniques used to determine the percentage of fertilizer phosphorus in the several crops showed that an inverse relationship exists between the native available phosphorus by soil test and the percentage of fertilizer phosphorus in the plant. A considerably higher percentage of plant phosphorus derived from fertilizer was found in this study than has been reported for similar crops grown under field conditions.

Examination of two chemically extracted fractions of available soil phosphorus during cropping showed that a high proportion of such phosphorus was derived from applied fertilizer when the original level of available phosphorus was low. Most of the extractable fertilizer phosphorus was found to be in the adsorbed form.

The use of radioactive phosphorus makes it possible to distinguish between native soil phosphorus and fertilizer phosphorus utilized by plants. Studies can now be made of the availability of various phosphatic fertilizers to crops grown under different soil conditions. This new tool will help to explain results obtained in previous field experiments as well as to permit new experiments on the chemistry of phosphorus in the laboratory and the field.

CONTROL OF POTATO-CHIP COLOR BY TREATMENT OF SLICES WITH GLUCOSE SOLUTIONS FOLLOWING AN ACID TREATMENT

By S. T. DEXTER and D. K. SALUNKHE
DEPARTMENT OF FARM CROPS

DENNY AND THORNTON[1] have shown that glucose is largely responsible for the coloration that develops in potato chips in the last stages of frying. They suggest that 4 parts per thousand parts of fresh tissue would be approximately the dividing line between too much and too little glucose from the viewpoint of color development. In two previous papers,[2, 3] it was shown that the glucose may be removed from the slices previous to frying and that very light colored chips result. By suitable treatment with dilute acids and other chemicals the permeability of the cell membrane was altered in such a manner that the glucose was almost completely extracted while much of the sucrose, as well as most of the soluble nitrogenous compounds, was retained in the slices.

In the previous experiments, such treatment sometimes produced batches of chips containing a certain proportion of chips that may be too light in color for commercial acceptance. Yet in non-uniform potatoes, overtreatment of slices low in sugar seems unavoidable if slices high in sugar are to be treated sufficiently. The purpose of the present experiments was to correct this difficulty and to reduce the variability of the color of chips from non-uniform potatoes in order that both groups, "too light" and "too dark," might be brought to the color desired.

In the present paper, experiments will be described in which a) the removal of the glucose is more completely controlled than with simple water extraction (Experiment 1), b) glucose is added to, or replaced

[1]Denny, F. E., and N. C. Thornton. Factors for color in the production of potato chips. Contrib. Boyce Thompson Inst. 11: 291-303. 1940.
[2]Dexter, S. T., and D. K. Salunkhe. Improvement of potato chip color by hot water treatment of slices. Mich. Agr. Exp. Sta. Quart. Bul. 34: 399-402. 1952.
[3]Dexter, S. T., and D. K. Salunkhe. Chemical treatment of potato slices in relation to the extraction of sugars and other dry matter and the quality of potato chips. Mich. Agr. Exp. Sta. Quart. Bul. 35: 102-109. 1952.

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in the extracted slices to any desired degree (Experiment 2), and c) the action of glucose and sucrose is contrasted (Experiment 3). Certain theoretical aspects will be discussed.

EXPERIMENT 1

Six Russet Rural potatoes were removed from 9 months of cold storage. Replicate samples were prepared by taking one slice from each tuber. These six slices were strung, in a fixed order, on cotton threads.

Samples were treated for 2 minutes with phosphoric acid at pH2 and a temperature of 120° F. These were then transferred for 8 minutes to water solutions containing 0, 2, 4, and 20 parts of chemically pure glucose, per thousand at 120° F. One may assume that the concentration of glucose in any slice approached the concentration of the glucose solution in which it was placed. The slices were fried in a standard manner, 385°F. initial temperature.

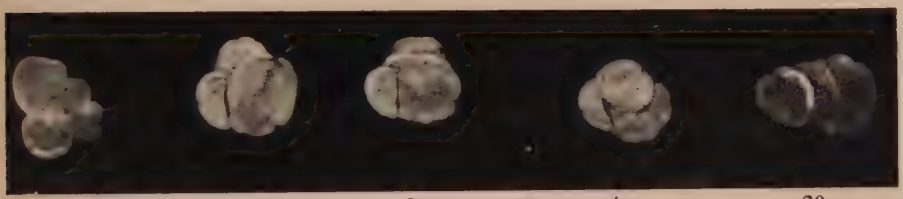

Fig. 1. The color of potato chips obtained by treating the raw slices in phosphoric acid, pH2, at 120° F. for 2 minutes, followed by soaking in water solutions of glucose, 0, 2, 4, and 20 parts per thousand, at 120° F. for 8 minutes. The control slices were soaked in cold water only for 10 minutes.

Figure 1 shows the fried slices. The colors of the chips produced were directly related to the concentration of the glucose solution in which they were soaked for 8 minutes. Similar concentrations of commercial glucose (corn syrup)[1] gave almost identical results.

EXPERIMENT 2

Similar samples of potato slices were treated with acid, as before, but were washed for 5 minutes in water (120 F.) rather than for 8 minutes. For the 3 additional minutes they were placed in water solutions containing 0, 2, 4 or 20 parts of glucose per thousand (120°F.),

[1]Karo product.

to infuse glucose of various concentrations into the slices. Preliminary experiments had shown that a period of 1 minute in the glucose solutions gave slightly less coloration, after frying, than a period of 3 minutes.

Figure 2 shows the fried slices. The 3-minute dip in glucose

Fig. 2. The color of potato chips obtained by treating the raw slices in phosphoric acid, pH2, at 120° F. for 2 minutes, followed by soaking in water at 120° F. for 5 minutes. They were then placed in glucose solutions, 0, 2, 4, and 20 parts per thousand for 3 minutes. The controls were soaked in cold water only for 10 minutes.

solution produced colorations such as in Fig. 1, in accordance with the concentration of the glucose solution.

EXPERIMENT 3

Other samples (newly harvested Russet Rurals) were treated with acid, but were washed for 60 hours in running tap water in an attempt

Fig. 3. The color of potato chips obtained by treating the raw slices in phosphoric acid, pH2, at 120° F. for 2 minutes, followed by washing in running tap water for 60 hours. The slices were then soaked in glucose (upper row), or sucrose (lower row) solutions, 0, 2, 4, 8, and 20 parts per thousand at 120° F. for 3 minutes. The control slices were fried after a brief washing in cold water.

to remove most of the soluble materials from the slices. These extracted samples were then dipped for 3 minutes in glucose and sucrose solutions, respectively, with concentrations of 0, 2, 4, 8 or 20 parts per thousand (120 F.). It may be seen in Fig. 3 that a 3-minute dip in glucose solution produced chips with colorations in proportion to the glucose concentration, but that the sucrose solutions seem essentially without effect on color. It is interesting to observe that the 4 parts per thousand suggested by Denny and Thornton seems an appropriate limit of glucose concentration for moderately colored chips. (Table 1).

TABLE 1—Color rating for potato chips

Fig.	Sugar	Concentration of sugar solution, p.p. thousand					
		control	0	2	4	8	20
Fig. 1	glucose	3.5	9.5	8.5	7	...	3
Fig. 2	glucose	5.0	9	8.3	6	...	3
Fig. 3—top	glucose	8.5	9	8	7	5.5	3
bottom	sucrose	8.5	9	9	9	9	8.7

The table gives the average color of the chips on a rating scale of 10 (almost colorless) to 1 (very dark), 7.5 to 10 acceptable and 8.5 to 9 most desired.

DISCUSSION

It appears possible to prepare potato chips of almost any desired shade of brown by using the methods described above. One might imagine a machine for treating slices that was composed of three compartments—an acid bath at about 120 F. in which the slices might remain for a minute or two; then a warm water washing bath in which they might remain for a somewhat longer time, perhaps 5 minutes; and finally a compartment containing a suitable glucose solution in which the extracted slices might remain for a final minute or two. Modifications of temperature, acid or glucose concentration could be made to suit any particular case.

The degree of discoloration developed by a known concentration of glucose varies strikingly from one region of a slice to another (Figs. 1 and 2). Even when slices were extracted for a long time with acid, hot water or dilute sodium hydroxide, this differential regional coloration in the chip could be brought out by treating with glucose solu-

tion. The extracted slices, when fried, might give a chip almost without color, or one having but very slight color in the center. Following a 3-minute dip in glucose 8 parts per thousand, the outer portion of the chip might be comparatively light in color, perhaps 7, while the center was dark, perhaps 3 on the color chart. Glucose may produce either a uniform (Fig. 3) or a differential darkening. Such a pattern of coloration may be due to a uniform, as contrasted with a regional, distribution of an insoluble material reacting with glucose. Or, in cases of uniform coloration, glucose alone may be responsible, as when paper disks, dipped in glucose, are fried. Certainly, it is difficult to believe that glucose alone is responsible for the color patterns seen in Figs. 1 and 2, although the color clearly did not develop in the absence of glucose. When one considers the rather severe treatments with both acid and base, he must conclude that the material reacting with glucose is comparatively insoluble. Other types of discoloration of chips appear to occur. These will be discussed in a later paper.

SUMMARY

Potato slices were treated with phosphoric acid of pH2 and washed in water to extract glucose from the slices. Such slices fry to give very light-colored chips. To add color to any desired degree, the extracted slices were dipped for 3 minutes in various concentrations of glucose. A concentration from 2 to 4 parts of glucose per thousand (0.2 to 0.4 percent) seemed suitable. Stronger solutions gave chips of an undesirably dark color.

MICHIGAN FARM BUSINESS REPORT FOR 1951

By J. C. DONETH, J. M. NIELSON, E. M. ELWOOD, W. H. VINCENT, and R. T. HARTWIG
AGRICULTURAL ECONOMICS EXTENSION

IT WAS ANOTHER good farming year in Michigan in 1951. This was revealed through an analysis of 685 farm account records kept by farmers throughout the state. The Agricultural Economics Department of Michigan State College, cooperating with the county agricultural agents, summarizes and analyzes the records.

Average results by years since 1929 are available for the state as well as for individual type-of-farming areas. This report summarizes some items over a 23-year period but presents in greater detail the results of the 685 Michigan farm records in 1951.

TABLE 1—Farm earnings on farm accounting farms in Michigan by years, 1929-51

Year	Labor income	Year	Labor income
1929	$ 585	1940	$ 787
1930	—263	1941	1,675
1931	—676	1942	2,303
1932	—595	1943	1,990
1933	249	1944	2,406
1934	565	1945	2,483
1935	764	1946	3,374
1936	1,318	1947	3,486
1937	569	1948	2,735
1938	571	1949	1,815
1939	780	1950	2,688
		1951	3,782
23-year average (1929-51)			$1,452

FARM EARNINGS

Net farm earnings on these account farms rose gradually during and after World War II years, hitting an unprecedented high in 1947 (Table 1). The post-war decline then set in, and earnings were almost

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cut in half by 1949. However, the war in Korea and the preparedness program reversed the direction again. The 1950 earning figure was very comparable to that of 1948. Then, in 1951 a new peak for labor income was reached of $3,782 per farm account farmer.

Labor income represents what is left for the farmer's labor and management after all cash expenses, depreciation, family labor, and 5 percent interest on the investment have been taken out of gross income. In addition, the farm operator receives the value of farm products used from the farm in the home.

While the figures in this report tend to reveal in a general way what is happening financially on Michigan farms, they do not represent the position of the average farmer. These account farms are 210 acres in size, compared with the average-sized Michigan farm of 111 acres in the 1950 census. Neither are the earning figures between years entirely comparable. Investment values were quite representative in

TABLE 2—Comparison of gross income, expenses and labor incomes on farm accounting farms in Michigan, 1935-39 average, and 1946-51 by years

Item	1935-39	1946	1947	1948	1949	1950	1951
INCOME							
Crops	$ 881	$2,641	$2,663	$2,223	$2,085	$2,372	$2,646
Dairy products	910	3,366	3,456	3,671	3,274	3,439	4,574
Cattle	338	894	1,082	1,209	1,094	1,719	2,165
Hogs	224	748	949	725	643	865	1,034
Poultry and eggs	256	711	805	827	782	810	992
Sheep	112	137	126	102	104	151	187
Other	161	221	351	415	387	447	497
	$2,882	$8,718	$9,432	$9,172	$8,369	$9,803	$12,095
EXPENSES							
Feed bought	261	921	1,231	1,190	1,062	1,192	1,502
Machinery	291	922	1,162	1,365	1,497	1,658	1,939
Hired labor	231	767	634	665	628	684	739
Crop expense	193	741	770	863	877	774	1,111
Family labor	197	418	468	509	469	449	487
Improvements	138	317	349	373	422	454	526
Taxes	74	118	128	138	146	168	185
Other	56	209	216	215	285	482	427
	$1,441	$4,413	$4,958	$5,358	$5,386	$5,861	$6,916
Net farm income	1,441	4,305	4,474	3,814	2,983	3,942	5,179
Interest on investment at 5%	641	931	988	1,079	1,168	1,254	1,397
LABOR INCOME	$ 800	$3,374	$3,486	$2,735	$1,815	$2,688	$3,782

the books 10 years ago but in most cases now are considerably too low to represent present-day figures. The purchasing power of each Labor Income dollar has changed drastically too. The $3,782 earning figure in 1951 would buy as much for the family as $1,681 bought during pre-war days. Then too, income taxes must now be paid out of this Labor Income figure.

THE 1951 SITUATION

Gross income per farm amounted to $12,095 in 1951 (Table 2). This is the highest on record and 23 percent above the $9,803 obtained in 1950. Prices received by Michigan farmers averaged 18 percent higher in 1951 which accounted for most of this increase. Higher production accounted for the balance. All items of income showed some gains although dairy products alone was responsible for about half.

Total expenses, including interest, also went up—going from $7,115 to $8,313. Over half of this was due to higher prices paid for items bought, which rose from an index of 256 the year before to 282 in 1951. All important expense items showed increases.

The increase of $2,292 in gross income and only $1,198 in expense resulted in labor incomes rising $1,094—going from $2,688 in 1950 to $3,782 in 1951. This represented a 41-percent increase. Another evidence of the improved position of farmers in 1951 was that the purchasing power of Michigan farm products rose from 102 to 106 during the year.

The financial side of farming, as shown in Table 2, has changed drastically over the last 10 years. The physical side of farming has also changed (Table 3). The size of the farm has increased from 162 to 210 acres. The number of livestock units has increased from 20.8 to 31.6 per farm. On the other hand, there was the equivalent of 1.9 men per farm in pre-war years and only 1.7 in 1951. The productive man-work units per man (a measure of labor efficiency) have increased from 228 to 319. An important factor causing this increased labor efficiency has been an increase in machinery investment of nearly four times per farm in the last 10 years.

TABLE 3—Comparison of size of farm, amount of livestock and amount of work, 1935-39 average, and 1946-51 by years, Michigan

Item	1935-39	1946	1947	1948	1949	1950	1951
Number of farms	1,150	838	830	846	912	826	685
Total acres	162	195	193	196	198	201	210
Tillable acres	107	133	134	136	136	138	146
Productive animal units	20.8	27.8	27.1	23.9	25.6	31.7	31.6
Productive man work units*	427	498	473	466	477	493	529
Number of men*	1.9	1.8	1.7	1.7	1.7	1.6	1.7
Work units per man*	228	284	286	281	292	303	319

*Fruit farms excluded.

TYPE-OF-FARMING AREA INFORMATION

The figures and information already presented pertain to an average of all farm account farms throughout the state. In addition to state average figures, the following tables (4, 5, 6 and 7) show information for all type-of-farming areas in the state (Fig. 1).

The labor income increase already discussed was general throughout Michigan except in the fruit areas represented here by the combined figures of areas 3 and 11. The low temperatures in the fall of 1950 reduced the peach and grape crops in 1951 to the lowest production in years. The cherry crop was down some from the year before.

There was an increased acreage of wheat, oats, and corn over 1950 but a sharp decrease in sugar beet and potato acreage. Crop yields were generally higher than in 1950 although a snow storm in November resulted in a considerable amount of corn not being harvested at top quality.

Livestock continued to be the chief source of income on the farms in this project (Table 4). Livestock and livestock products contributed an income of $8,952 per farm in 1951 which amounted to 74 percent of the total. Crops contributed 22 percent and miscellaneous sources 4 percent.

It should be kept in mind that the farmers who kept the record books from which these tables were made were not necessarily typical of all farmers. Also, the farms in one area may be less representative than those in other areas. Figure 1 shows the counties included in each area.

TABLE 4—Financial summary of 685 Michigan farm account farms by type-of-farming areas, 1951

Item	All farms	Type-of-farming areas														
		1	2	3&11	4	5	6	7	8	9	10	12	14	15	16	17
Number of farms	685	79	57	31	38	141	35	33	48	31	46	41	28	17	17	43
Total acres	210	182	230	154	165	239	224	228	166	249	221	278	204	222	204	150
Percent of farm acres tillable	70	79	80	71	74	75	78	80	77	51	62	55	51	65	47	46
Tillable acres	146	144	183	110	122	179	175	182	127	126	137	152	105	144	96	69
Real estate (less house)	$14,264	$16,438	$15,844	$20,108	$11,609	$18,414	$17,796	$17,067	$17,295	$10,082	$10,721	$ 8,693	$ 7,665	$ 6,742	$ 9,437	$ 5,591
Machinery and equipment	6,090	6,279	6,292	7,072	6,181	7,222	7,652	6,847	6,637	4,966	5,403	4,917	4,130	4,061	5,185	3,608
Livestock	4,579	5,776	5,786	2,733	4,268	6,053	5,596	5,179	4,328	4,752	3,463	2,892	2,454	2,937	3,027	1,870
Feed and crops	3,030	4,260	3,501	2,883	3,127	3,996	3,621	2,957	3,861	1,578	2,118	2,123	1,284	1,472	1,196	1,016
Capital investment*	$27,963	$32,753	$31,423	$32,796	$25,185	$35,685	$34,665	$32,050	$32,121	$21,378	$21,705	$18,625	$15,533	$15,212	$18,845	$12,085
Livestock income	$ 8,952	$10,600	$12,008	$ 4,442	$11,177	$11,182	$10,751	$ 9,970	$ 9,033	$7,539	$ 7,362	$ 5,158	$ 5,172	$ 6,156	$ 7,374	$ 4,057
Crop income	2,646	2,766	3,210	10,758	1,346	2,999	2,642	2,040	3,804	642	2,236	1,993	1,158	466	441	207
Other income	497	386	587	517	426	554	526	520	564	364	502	469	250	448	462	610
Gross income	$12,095	$13,752	$15,805	$15,717	$12,949	$14,735	$13,919	$12,530	$13,401	$ 8,545	$10,100	$ 7,620	$ 6,580	$ 7,070	$ 8,277	$ 4,874
Total expense†	6,916	7,581	9,388	11,312	7,938	7,788	8,256	7,609	7,069	4,640	5,784	4,662	3,665	3,603	5,113	2,837
Net farm income	$ 5,179	$ 6,171	$ 6,417	$ 4,405	$ 5,011	$ 6,947	$ 5,663	$ 4,921	$ 6,332	$ 3,905	$ 4,316	$ 2,958	$ 2,915	$ 3,467	$ 3,164	$ 2,037
Less interest @ 5%	1,397	1,638	1,572	1,640	1,259	1,774	1,733	1,602	1,606	1,069	1,083	931	777	760	943	604
Labor income 1951	$ 3,782	$ 4,533	$ 4,845	$ 2,765	$ 3,752	$ 5,173	$ 3,930	$ 3,319	$ 4,726	$ 2,836	$ 3,233	$ 2,027	$ 2,138	$ 2,707	$ 2,221	$ 1,433
Labor income 1950	2,688	3,389	3,309	3,239	2,885	3,687	2,856	1,249	4,057	1,986	2,300	830	923	1,856	1,416	1,146
Labor income 1949	1,815	2,079	2,160	1,065	1,927	2,647	2,534	2,543	2,955	930	1,564	873	917	576	1,625	309
Labor income 1948	2,735	3,954	2,903	1,962	2,930	3,014	3,042	3,267	3,777	2,482	2,517	2,000	1,233	1,491	2,960	1,657
Labor income 1947	3,486	4,596	4,300	1,930	3,753	4,710	3,793	2,720	4,501	2,310	2,391	1,617	2,094	2,355	3,050	1,668
Labor income 1946	3,374	4,337	3,169	6,007	3,011	3,312	2,988	3,585	4,413	2,489	2,485	2,221	2,066	2,267	2,954	2,357
Labor income 1945	2,483	3,432	2,464	5,051	2,710	3,228	2,807	2,181	2,978	1,514	2,226	1,554	1,613	1,345	1,766	1,653
Labor income 1944	2,406	2,719	1,452	4,684	2,409	2,496	2,712	2,753	2,940	1,815	2,393	1,819	1,613	1,661	1,850	1,551
Labor income 1943	1,990	2,235	2,473	4,033	2,101	2,222	2,378	1,502	2,272	929	1,704	1,380	1,098	670	1,683	1,080
Labor income 1942	2,303	3,056	2,389	2,722	2,142	2,763	2,856	2,673	2,543	1,636	2,330	1,489	1,253	1,346	1,601	1,193
Labor income, 10 yr. ave. '42-51	$ 2,706	$ 3,433	$ 2,946	$ 3,346	$ 2,762	$ 3,325	$ 2,990	$ 2,579	$ 3,516	$ 1,893	$ 2,314	$ 1,581	$ 1,495	$ 1,627	$ 2,113	$ 1,405

*Investment figures tend to represent long-time account book values and not present day valuations.
†Includes family labor, but not operator's labor or interest on investment.

TABLE 5—Kinds of crops and percentage of tillable land in different crops and also yields by type of farming areas in Michigan, 1951

Item	All farms	Type-of-farming areas														
		1	2	3&11	4	5	6	7	8	9	10	12	14	15	16	17
Number of farms	685	79	57	31	38	141	35	33	48	31	46	41	28	17	17	43
Number of tillable acres	146	144	183	110	122	179	175	182	127	126	137	152	105	144	96	69
Percent in sod crops	45	35	43	30	39	42	48	48	35	57	51	56	64	65	63	69
Percent in legumes	35	28	33	23	34	35	36	36	29	45	42	34	51	42	40	35
Percent tillable acres in:																
Tillable pasture	17	13	20	11	13	16	20	19	13	20	18	21	23	20	17	16
Alfalfa hay	17	18	18	12	17	18	17	16	15	20	20	13	24	2	18	6
Other hay	11	4	4	7	8	6	12	12	6	16	13	21	16	42	28	47
Corn (includes silage)	17	28	18	11	21	20	14	10	19	15	14	11	5	.....	9	.....
Wheat	11	13	14	3	15	16	10	9	12	4	8	2	4	3	.....	1
Oats (oat mixtures)	14	16	21	7	18	14	15	16	14	13	14	12	14	20	17	20
Barley	1	.....	1	.....	.....	.....	.....	.....	3	2	.....	.....	3	.....	2	1
Beans	2	.....	.....	.....	.....	.....	3	8	9	1	.....	.....	.....	.....	.....	.....
Sugar beets	.....	.....	.....	.....	.....	.....	.....	2	6	.....	.....	.....	.....	.....	.....	.....
Potatoes	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4	1	.....	.....	.....
Fruit and truck	2	.....	.....	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other	4	5	1	.....	4	3	4	4	2	4	7	8	6	10	5	4
Idle	4	3	2	5	3	5	5	4	1	5	5	8	3	3	4	5
Seeds	.....	.....	1	.....	1	2	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Crop yield per acre:																
Alfalfa hay	2.1	2.3	2.1	1.9	2.2	2.4	2.1	2.2	2.3	2.1	1.7	1.5	1.6	1.6	2.3	1.7
Other hay	1.7	1.7	1.6	1.6	1.9	2.1	1.8	1.7	2.0	1.7	1.4	1.3	1.5	1.4	1.6	1.8
Corn, silage	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.0	.....
Corn, shelled	51	55	51	51	46	53	44	41	52	32	38	36	29	.....	.....	.....
Wheat	29	27	25	42	24	27	27	22	34	29	25	25	26	17	.....	20
Oats	44	43	43	46	49	46	45	35	53	43	42	35	47	46	49	39
Barley	33	.....	31	.....	.....	.....	.....	.....	.....	26	.....	.....	33	.....	31	19
Beans	.....	.....	.....	.....	.....	.....	14	13	22	11	.....	.....	.....	.....	.....	.....
Sugar beets	.....	.....	.....	.....	.....	.....	.....	5.6	11.9	.....	.....	.....	.....	.....	.....	.....
Potatoes	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	332	218	349	.....	.....	.....
Crop yield index	100	104	96	99	99	106	88	87	114	92	85	75	87	89	103	99
Crop sales and PMA payments	$ 2,240	$ 2,222	$ 2,197	$10,691	$ 1,162	$ 2,081	$ 2,339	$ 1,825	$ 3,808	$ 393	$ 2,112	$ 1,835	$ 795	$ 641	$ 362	$ 374
Crop income, total	2,646	2,766	3,210	10,758	1,346	2,999	2,642	2,040	3,804	642	2,236	1,993	1,158	466	441	207
Feed bought	1,502	2,133	2,828	1,165	2,941	1,521	1,382	1,311	1,293	813	1,153	592	721	822	1,282	569

TABLE 6—Livestock: Kinds, amounts and returns from livestock by type-of-farming areas in Michigan, 1951

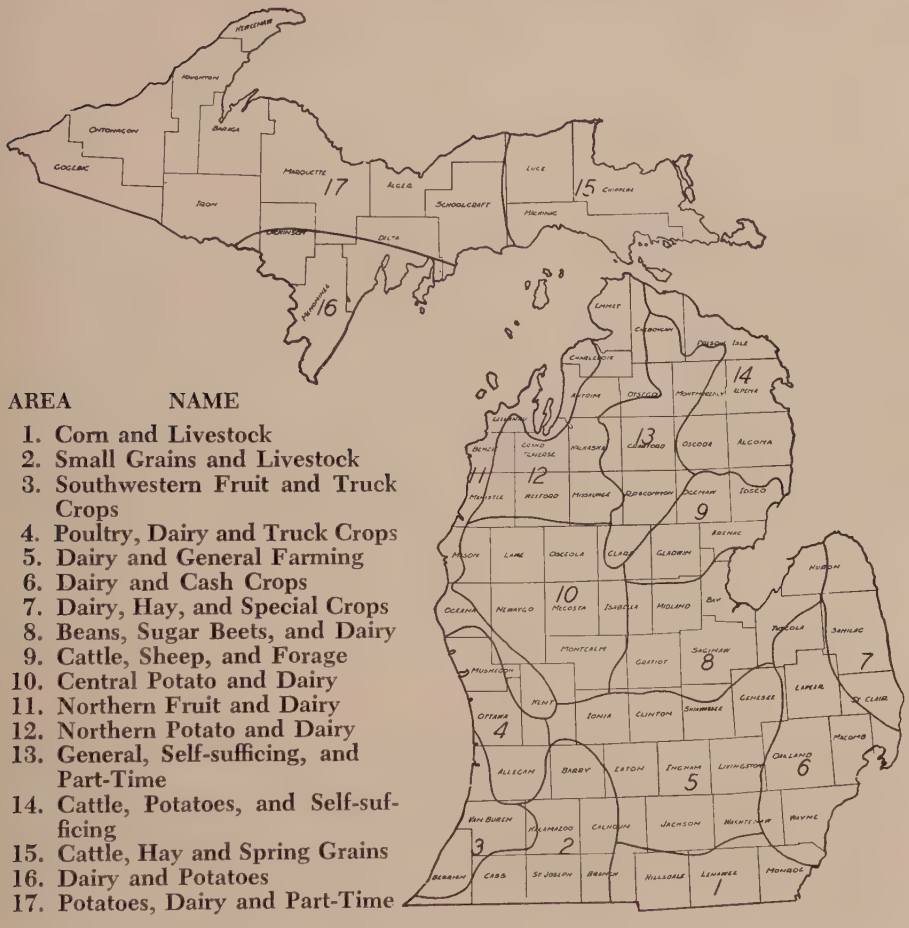
Item	All farms	Type-of-farming areas														
		1	2	3&11	4	5	6	7	8	9	10	12	14	15	16	17
Number of farms	685	79	57	31	38	141	35	33	48	31	46	41	28	17	17	43
Livestock income, total	$ 8,952	$10,600	$12,008	$ 4,442	$11,177	$11,182	$10,751	$ 9,970	$ 9,033	$ 7,539	$ 7,362	$ 5,158	$ 5,172	$ 6,156	$ 7,374	$ 4,057
Livestock income per T.A.*	62	74	66	40	92	63	61	55	71	60	54	34	49	43	77	59
Productive animal units	31.6	37.5	44.3	15.7	33.1	39.6	33.1	32.0	32.9	32.2	28.1	25.1	21.4	22.5	26.8	17.7
Tillable acres per P.A.U.†	4.6	3.8	4.1	3.9	3.7	4.5	5.3	5.7	3.9	3.9	4.9	6.0	4.9	6.4	3.6	3.9
CATTLE:																
Percent farms reporting	97	96	100	68	97	98	100	100	98	100	100	98	100	100	100	100
Cows per farm reporting	14.1	12.1	15.0	10.3	14.0	16.1	16.7	17.7	13.2	14.0	13.3	12.4	9.9	11.3	18.2	11.8
Dairy sales per cow	$ 335	$ 368	$ 334	$ 326	$ 346	$ 355	$ 401	$ 375	$ 368	$ 287	$ 312	$ 249	$ 248	$ 264	$ 317	$ 263
Dairy sales per farm reporting	4,726	4,461	5,017	3,370	4,833	5,703	6,685	6,632	4,874	4,026	4,167	3,078	2,456	2,987	5,761	3,089
Income per farm reporting	2,236	2,632	2,569	1,745	2,190	2,727	2,456	2,619	2,254	2,568	1,894	1,536	1,846	1,608	1,404	768
HOGS:																
Percent farms reporting	58	80	74	26	55	60	43	18	79	74	54	76	79	41	35	16
Sows per farm reporting	3.4	4.8	6.8	1.1	2.6	4.7	1.0	2.0	2.8	2.4	1.3	1.9	.5	1.0	.7	.6
Litters farrowed per farm	6.0	8.7	12.5	2.0	4.3	8.4	1.8	3.5	4.6	3.4	2.4	3.0	.8	.9	.8	.7
Pigs weaned per litter	6.7	6.5	6.7	5.4	6.7	6.3	6.9	7.3	7.8	6.8	7.6	7.4	7.7	8.3	5.6	7.4
Hog income per litter	$ 297	$ 341	$ 300	$ 213	$ 266	$ 289	$ 256	$ 118	$ 333	$ 228	$ 286	$ 183	‡	$ 213	‡	‡
Income per farm reporting	1,776	2,973	3,746	426	1,151	2,432	461	412	1,516	774	674	554	372	183	53	138
SHEEP:																
Percent farms reporting	13	16	23	.....	.....	23	.....	6	8	26	.....	5	11	18	6	.....
Ewes per farm reporting	37	12	46	.....	.....	48	.....	20	36	31	.....	50	24	28	8	.....
Lambs raised per 100 ewes	99	88	90	.....	.....	100	.....	108	121	94	.....	104	124	131	100	.....
Sheep income per ewe	$ 39	$ 33	$ 33	.....	.....	$ 40	.....	$ 29	$ 40	$ 26	.....	$ 16	$ 43	$ 40	‡	.....
Income per farm reporting	1,453	892	1,489	.....	.....	1,955	.....	571	1,669	798	.....	814	1,022	1,128	119	.....
POULTRY:																
Percent of farms reporting	70	75	70	61	89	78	74	70	79	61	54	61	82	82	53	40
Hens per farm reporting	154	188	187	210	443	126	172	121	121	50	133	61	55	157	67	54
Egg sales per hen	$ 6.75	$ 7.23	$ 7.58	$ 5.02	$ 7.47	$ 6.35	$ 6.75	$ 5.53	$ 6.21	$ 3.27	$ 7.57	$ 4.37	$ 5.61	$ 7.98	$ 4.99	$ 6.56
Egg sales per farm reporting	1,040	1,361	1,414	1,057	3,305	801	1,160	667	754	164	1,004	268	308	1,252	333	354
Income per farm reporting	374	324	468	358	811	506	312	207	147	104	715	58	262	310	12	96

*T.A.—Tillable acres †P.A.U.—Productive animal units ‡Data not comparable

TABLE 7—Expenses and efficiency factors, labor, machinery, improvements and other costs by type-of-farming areas in Michigan, 1951

Item	All farms	Type-of-farming areas														
		1	2	3&11	4	5	6	7	8	9	10	12	14	15	16	17
Number of farms	685	79	57	31	38	141	35	33	48	31	46	41	28	17	17	43
Gross income per T. A.	$ 83.10	$ 95.39	$ 86.51	$142.93	$106.16	$ 82.50	$ 79.41	$ 68.94	$105.21	$ 67.38	$ 73.55	$ 50.27	$ 62.77	$ 49.18	$ 85.90	$ 70.76
Total expense per T.A.*	57.36	63.19	59.62	116.40	77.23	51.99	55.70	49.67	67.07	46.68	52.54	39.24	47.43	34.02	66.77	59.10
Total expenses*	8,349	9,109	10,891	12,800	9,421	9,285	9,764	9,029	8,543	5,890	7,215	5,948	4,971	4,891	6,433	4,070
Man labor:																
Number of men†	1.7	1.6	1.8	2.8	1.7	1.7	1.8	1.8	1.7	1.6	1.6	1.7	1.5	1.5	1.6	1.4
Income per man	$ 7,066	$ 8,691	$ 8,772	$ 5,613	$ 7,665	$ 8,578	$ 7,636	$ 6,823	$ 7,667	$ 5,345	$ 6,321	$ 4,588	$ 4,505	$ 4,695	$ 5,192	$ 3,565
Days of work per man†	319	335	341	.....	332	350	316	321	302	292	299	261	226	255	281	223
Hired	$ 739	$ 457	$ 896	$ 3,390	$ 958	$ 698	$ 1,001	$ 743	$ 663	$ 273	$ 675	$ 414	$ 292	$ 368	$ 462	$ 213
Family	487	479	535	493	350	516	547	635	628	620	379	526	348	292	326	355
Operator	1,433	1,528	1,503	1,488	1,483	1,497	1,508	1,420	1,474	1,250	1,431	1,286	1,306	1,288	1,320	1,233
Expenses per T.A.	18.27	17.09	16.06	48.84	22.88	15.18	17.43	15.39	21.71	16.99	18.09	14.69	18.57	13.55	21.87	26.15
Power and machinery:																
Investments	$ 6,090	$ 6,279	$ 6,292	$ 7,072	$ 6,181	$ 7,222	$ 7,652	$ 6,847	$ 6,637	$ 4,966	$ 5,403	$ 4,917	$ 4,130	$ 4,061	$ 5,185	$ 3,608
Income per $1000 investment	1,986	2,190	2,512	2,222	2,095	2,047	1,819	1,830	2,019	1,711	1,869	1,550	1,593	1,741	1,596	1,351
Annual expense	1,939	2,095	2,210	2,227	1,643	2,362	2,469	2,333	2,146	1,431	1,653	1,576	1,173	1,168	1,658	931
Expense per T.A.	13.32	14.53	12.10	20.25	13.47	13.23	14.09	12.84	16.84	11.34	12.04	10.40	11.20	8.12	17.21	13.52
Improvements:																
Investment (less house)	$ 6,809	$ 8,513	$ 7,472	$ 7,537	$ 6,078	$ 9,056	$ 8,144	$ 7,721	$ 8,045	$4,676	$ 5,179	$ 3,962	$ 3,423	$ 2,823	$ 4,726	$ 2,988
Investment per P.A.U.	215	227	169	.....	184	229	246	242	244	145	184	158	160	125	177	169
Annual expense	526	639	674	547	442	690	658	579	594	388	408	319	288	251	303	201
Expense per T.A.	3.62	4.44	3.69	4.97	3.62	3.86	3.75	3.19	4.67	3.07	2.98	2.10	2.74	1.74	3.16	2.92
Feed bought	$ 1,502	$ 2,133	$ 2,828	$ 1,165	$ 2,941	$ 1,521	$ 1,382	$ 1,311	$ 1,293	$ 813	$ 1,153	$ 592	$ 721	$ 822	$ 1,282	$ 569
Crop expense	935	950	1,240	2,331	799	1,070	1,146	1,046	947	533	837	719	430	328	562	218
Custom work	176	237	243	145	141	195	245	255	165	171	194	93	117	101	108	110
Taxes	185	208	232	199	215	245	207	190	204	112	133	111	65	79	90	50
Other expense	427	383	530	815	449	491	601	517	429	299	352	312	231	194	322	190
Feed bought per T.A.	$ 10.32	$ 14.79	$ 15.48	$ 10.60	$ 24.11	$ 8.52	$ 7.89	$ 7.21	$ 10.16	$ 6.44	$ 8.40	$ 3.90	$ 6.88	$ 5.72	$ 13.30	$ 8.26
Crop expense (less custom) per T.A.	6.42	6.59	6.79	21.19	6.55	5.99	6.54	5.75	7.43	4.22	6.09	4.74	4.10	2.28	5.83	3.18
Custom work per T.A.	1.21	1.64	1.33	1.32	1.16	1.09	1.18	1.40	1.30	1.36	1.41	.62	1.12	.70	1.12	1.59
Real estate taxes per T.A.	1.27	1.44	1.27	1.81	1.76	1.37	1.40	1.04	1.60	.89	.97	.74	.62	.55	.94	.73
Other expenses per T.A.	2.93	2.67	2.90	7.42	3.68	2.75	3.42	2.85	3.36	2.37	2.56	2.05	2.20	1.36	3.34	2.75

*Includes operator's and family labor, but not interest on investment. †Fruit farms excluded.



AREA NAME

1. Corn and Livestock
2. Small Grains and Livestock
3. Southwestern Fruit and Truck Crops
4. Poultry, Dairy and Truck Crops
5. Dairy and General Farming
6. Dairy and Cash Crops
7. Dairy, Hay, and Special Crops
8. Beans, Sugar Beets, and Dairy
9. Cattle, Sheep, and Forage
10. Central Potato and Dairy
11. Northern Fruit and Dairy
12. Northern Potato and Dairy
13. General, Self-sufficing, and Part-Time
14. Cattle, Potatoes, and Self-sufficing
15. Cattle, Hay and Spring Grains
16. Dairy and Potatoes
17. Potatoes, Dairy and Part-Time

Fig. 1. Type-of-farming areas in Michigan.

AN ORGANIC SOIL SAMPLER WITH TELESCOPING HANDLE[1]

By J. F. DAVIS and G. W. FRENCH

Department of Soil Science, Michigan State College; and Division of Farm Machinery, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture

In examinations of organic soil profiles it is often desirable to obtain exploratory samples to a depth of 5 feet or more. At the present-time, jointed sections are used to extend the length of soil augers. These sections usually consist of standard pipe or rods of suitable length, joined by threaded couplings. Two wrenches are required to dis-assemble the sections. The necessity of carrying two wrenches and extra sections makes this arrangement cumbersome. A sampler with telescoping handle is herein described (Figs. 1, 2, 3). Its extendable handle permits sampling to a depth of 5½ feet without extra sections and requires only a small Allen set-screw key for making the adjustment.

PARTS AND SPECIFICATIONS

The separate parts of this sampler are shown in Figs. 1 and 3, and the specifications for each are listed below.

1. Bushing. Shrink fit on shaft (2) and machine outside diameter for shrink fit in cylinder (8). Exact measurements of tubing used determine dimensions for matching bushings.

2. Outside telescopic section. Seamless steel tubing ⅞″ O. D. 31-3/16″ with 0.095″ wall thickness.

3. Reinforcing collar. Shrink fit and tapped for 5 16″-18 thread and equipped with Allen set screws with a conical point to fit 118° included angle.

4. Inside telescopic section. Seamless steel tubing 21 32″ O. D. x 30¾″ with 0.095″ wall thickness. Cross member ¾″ standard pipe x 10¾″ threaded in each end with ⅞″-14 to a depth of ¾″. This cross member is welded to the shaft. Depressions are countersunk in pairs

[1]This sampler is a modified design of one believed to be of European origin.

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90° apart and so spaced along the shaft as shown in Fig. 3. This provides for locking the telescoping sections in place.

5. Knurled plug. Plugs screw in each end of the handle cross member thus making a compartment for small items.

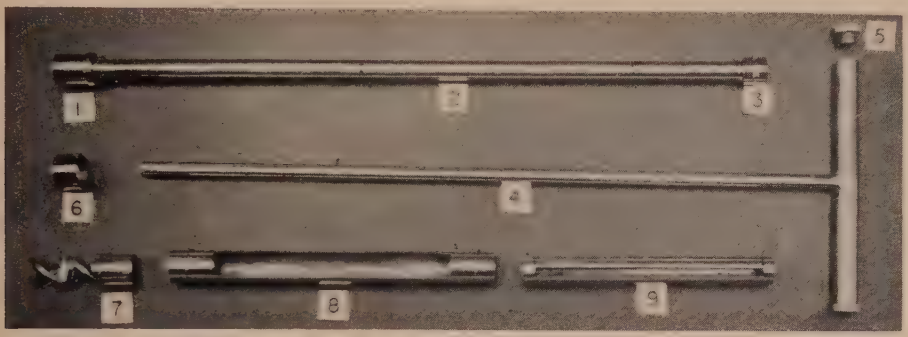

Fig. 1. Telescopic organic soil sampler (before assembly). (1) Bushing; (2) outside telescopic section; (3) bushing tapped and threaded for Allen set screws; (4) inside telescopic section; (5) knurled screw plug for handle; (6) reinforcing collar for sampler cylinder (8); (7) auger bit; (8) outside section of sampler cylinder; (9) inside section of sampler cylinder.

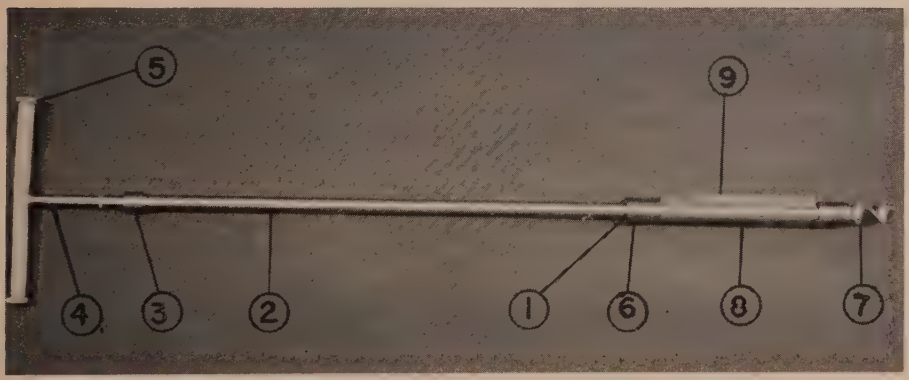

Fig. 2. Telescopic organic soil sampler (assembled). Numbers refer to parts shown in Figs. 1 and 3.

6. Reinforcing collar. Shrink fit.

7. Auger bit (1½″) welded to end plug and plug machined for shrink fit in cylinder (8).

8. Outside sampler cylinder. Fabricated from seamless steel tubing, 1 7/16″ O. D. x 12″, wall thickness 0.067″ with slot 1″ x 10¼″ (Fig. 3). Shrink fits for parts (1) and (7).

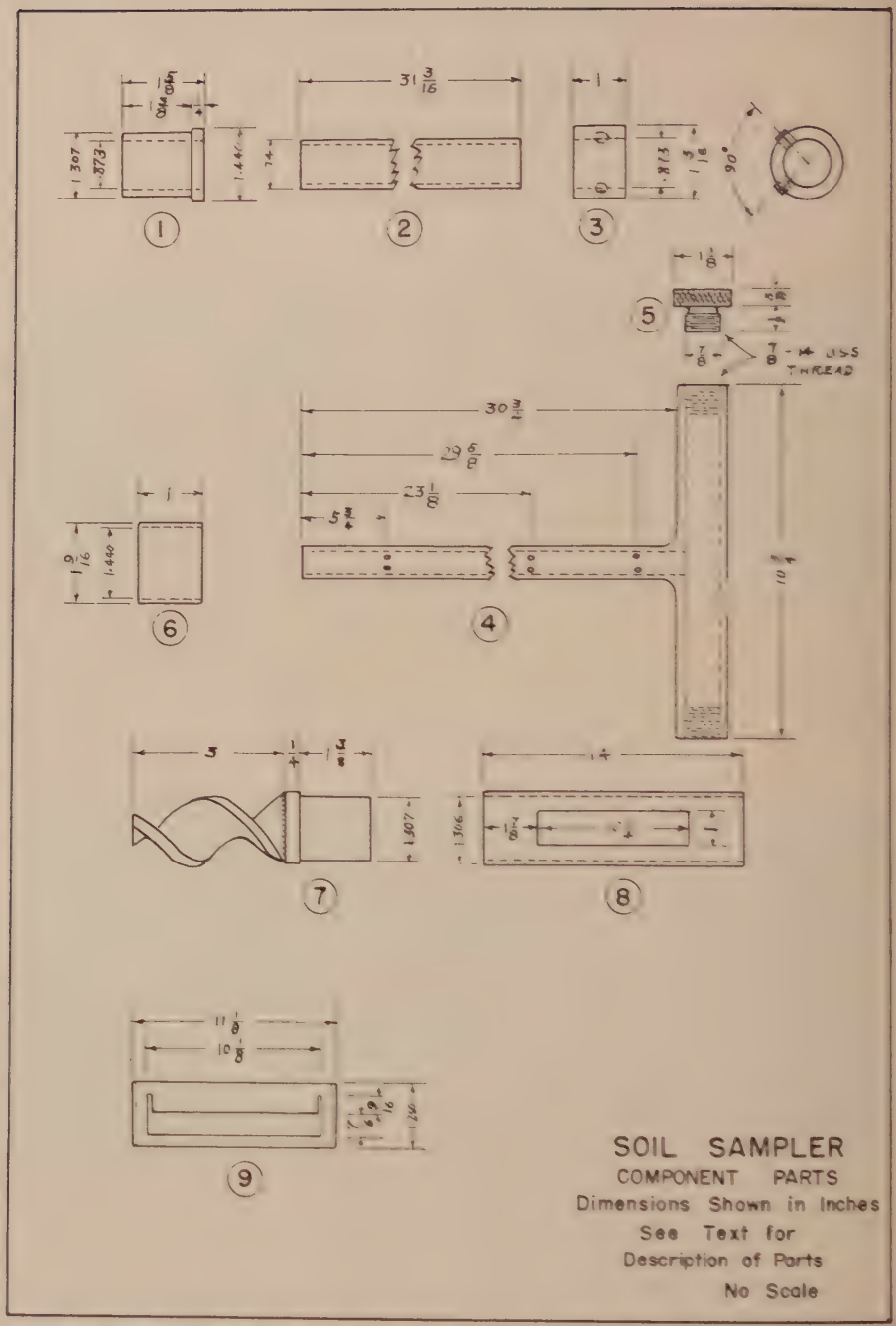

Fig. 3. Working drawing for construction of organic soil sampler. (Shrink fits were employed in the assembly of this sampler. Dimensions shown for the the parts fabricated are based on the actual size of the stock tubing procured. Since certain allowable tolerances are permitted in the manufacture of this type of tubing, the necessary modifications must be made to conform with any departure from the above-stated measurements.)

9. Inside sampler cylinder. Fabricated from seamless steel tubing, 1¼" O. D. x 11⅛", wall thickness 0.065". A thin steel disk is brazed in each end.

INSTRUCTIONS FOR ASSEMBLY

After machining the various parts to proper dimensions, bushing (1) is heated and shrunk on the outer telescopic section (2). Bushing (3) is likewise fitted on the same telescopic section.

Two holes, 90° apart, are drilled through bushing (3) and threaded for U. S. S. 5/16-18 thread.

The inner cylinder (9) is inserted in the outer cylinder (8) and the lip bent outward so that it projects approximately ⅜ inch above the circumference of the outer cylinder. The cylinder wall along the line where the bend is desired is thinned with a milling cutter to make a flat 3/16" in width. This bending operation is accomplished by inserting a flat bar ⅛" x ¾" and turning to produce a camming action. A flat bar ⅛" x 2" x 10" is placed in the cylinder to protect the opposite edge during the bending operation. It is important to assemble the cylinder so that the pressure against the lip causes the inner cylinder to rotate, thus closing the opening in the outer cylinder as the sampler is forced into the ground with a clockwise rotation.

The bushing (1) at the end of the outer telescopic section (2) and auger bit (7) is then shrunk fit into the proper ends respectively of the completed cylinder assembly. Reinforcing collar (6) is then shrunk fit in place (Fig. 2).

When sampling depths are greater than 5½ feet, another telescopic section similar to (2) can be made. Bushing (1) is omitted and a 5" section of tubing (4) is welded on the end of the larger tubing.

Be sure that the handle set screws are properly positioned in the indentations of the inner section of the handle and tightened securely.

Precision in machining parts (1), (3), (6), and (7) is very important. If shrink fits are too loose the cylinder assembly may be lost in the soil. If too much negative clearance exists assembly may be difficult or impossible. As an alternative method the cylinder may be attached to the telescopic sections and auger bit with cap screws.

The total weight of the sampler is approximately eight pounds.

USE OF SAMPLER

When the desired depth is reached the sampler is rotated in a counter-clockwise direction causing pressure against the lip to rotate the inner cylinder to uncover the opening in the outer cylinder and fill the inner cylinder with soil. The sampler is then rotated in a clockwise direction, thus closing the cylinder opening and preventing contamination of the sample when withdrawing the sampler.

EMMET COUNTY (MICHIGAN) POULTRY MARKETING SURVEY

K. D. McALVEY,[1] *L. E. DAWSON and J. A. DAVIDSON*[2]
DEPARTMENT OF POULTRY HUSBANDRY

EMMET COUNTY is located in the extreme northern portion of the Lower Peninsula of Michigan. The 1950 census[3] has reported a population of only 16,534 persons in the county. There are no large cities. Typical of many counties in the northern part of Michigan, the summer population is increased by tourists and summer residents. Because of the seasonal nature of its market and the long distance to other consuming areas, many agricultural production and distribution problems arise. One of these is in the poultry enterprise.

Two-thirds of the farms in Emmet County had chickens January 1, 1950, either for personal home use or as a supplement to farm income. Only five farms were classified as poultry farms.[3]

The "native" population of Emmet County consumed an estimated six and one-half million eggs in 1950. On January 1, 1950, there were 23,328 hens and pullets on farms,[3] which laid an estimated 3.7 million eggs in 1950. Therefore, an estimated 2.8 million eggs were imported. This does not include those consumed by the tourists.

This marketing survey was conducted to discover and evaluate the poultry and egg marketing practices of Emmet County poultry producers. A second objective was to obtain information concerning the size and importance of the poultry enterprise and to find out if a need exists for more adequate marketing facilities for poultry and eggs within the county.

Questionnaires were mailed to all farmers in Emmet County whose names were on the County Agricultural Agent's mailing list. A total of 673 farmers were contacted, and 70 questionnaires were completed sufficiently for analysis and returned. Some farmers do not raise poul-

[1]Instructor in Agriculture, Petoskey Public Schools, Petoskey, Michigan.

[2]The authors wish to acknowledge the cooperation of Robert S. Lincoln, County Agricultural Agent, Emmet County, and the assistance of all farmers, buyers and retailers who participated in this survey.

[3]1950 U.S. Census of Agriculture—Michigan.

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try and, therefore, could not answer the questionnaire. Some farmers failed to answer all questions; therefore, this analysis was based on the percentage or number of answers to each question and not on the basis of the 70 returned questionnaires. A portion of this report is based on these returns.

A personal survey was also conducted in 22 grocery stores, restaurants and hotels in the county.[4] These businesses were selected as representatives of the distributors of poultry and eggs in the county. Grocery "Super Markets," neighborhood grocery stores, restaurants and hotels were chosen in several cities and towns in the county for this survey. This survey was planned to show the relationship between the supply of and demand for poultry products in the county.

FARM SURVEY

FLOCK REPLACEMENTS

Source of Chicks—The 53 farmers who reported, purchased chicks from 26 different hatcheries located in 7 states. Michigan hatcheries supplied about 75 percent of these farmers, while the others purchased chicks from Ohio, Indiana, Illinois, Iowa, Missouri or Pennsylvania. No chicks were reported as being purchased in Emmet County, but eight farmers purchased chicks from near-by Boyne City in Charlevoix county.

Time of Purchase—Only one farmer purchased chicks in December, but he purchased 16.7 percent of all chicks reported. Over 70 percent of the chicks were purchased in March, April or May, and only 20 percent were purchased earlier. The March-hatched pullets would probably start to lay in late August or early September, but would be producing few large eggs before the summer tourists had departed (Fig. 1).

Breed Popularity—White Rocks were the most popular breed reported and White Leghorns were next in importance. These two accounted for 68 percent of the flocks. Figure 2 shows the popularity of all breeds reported.

Age and Sex of Chicks—Nearly four-fifths of the farmers purchased day-old chicks. A small percentage purchased chicks which were either 1 week old, 1 month old, 6 weeks old or older.

Over two-thirds of the producers purchased "straight-run" chicks and only 30 percent purchased sexed pullets.

[4]Three hotels, 5 restaurants, 3 super-markets, and 11 neighborhood grocery stores.

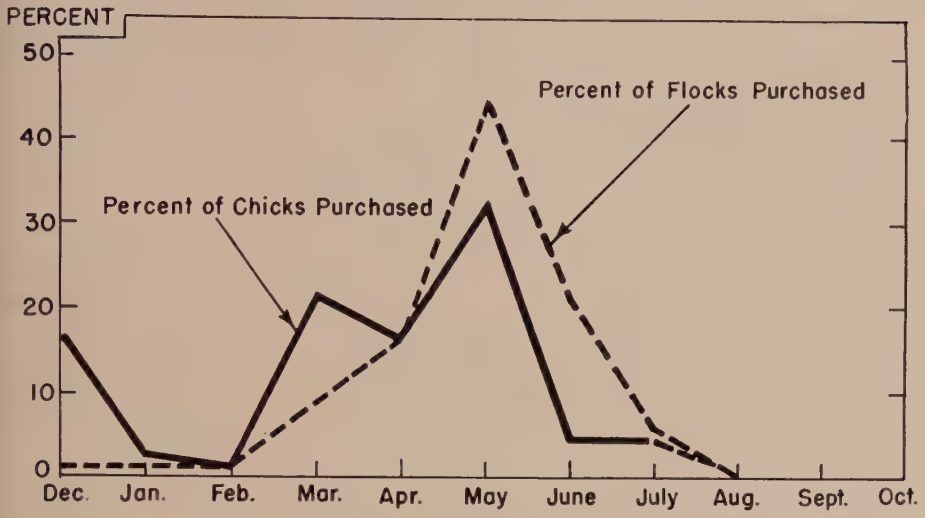

Fig. 1. Monthly variations in chick purchases.

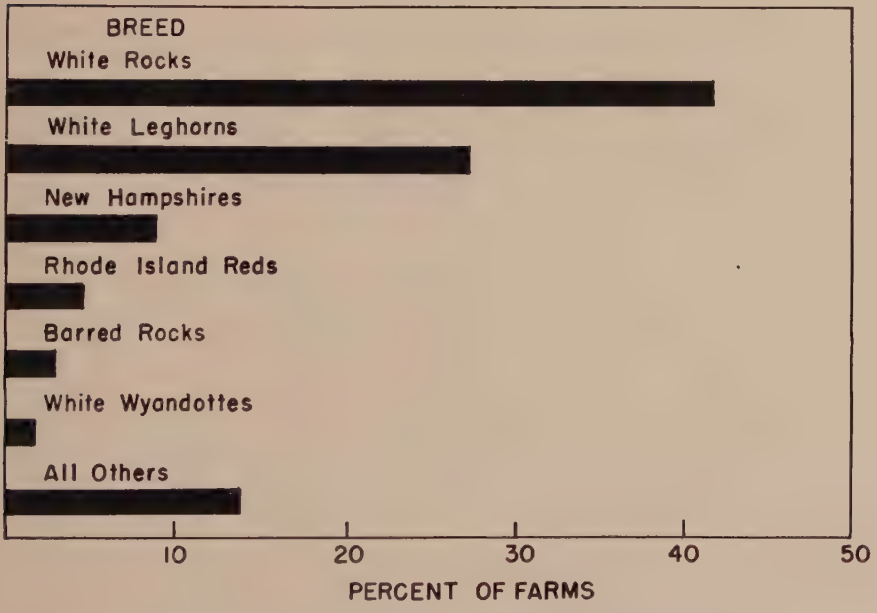

Fig. 2. Popularity of poultry breeds in Emmet County.

Source of Feed—Two-thirds of the farmers purchased one-half or more of their feed. Sixty percent of the farmers purchased all their feed ready mixed. Only 16 percent bought whole grain and mixed their own feed, while 11 percent bought part "ready mixed" feed and part whole grain.

The capacity of present housing conditions was determined by asking how many hens were kept and how many could be kept in the present houses. Over half of the farmers had capacity for between 50 and 200 hens. Thirty-two percent had room for less than 50 hens and only 14 percent had room for 200 or more (Fig. 3).

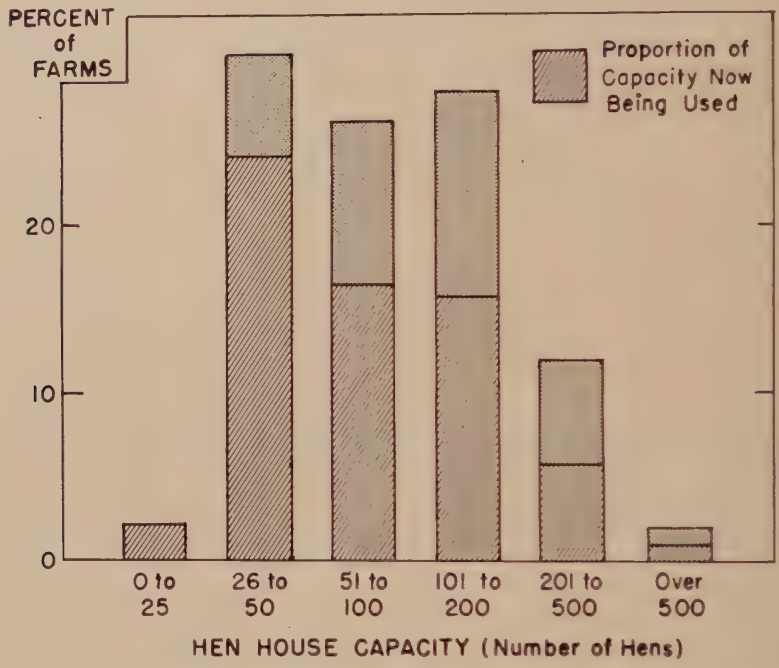

Fig. 3. Laying house capacity and proportion of that capacity now being used.

As shown in Fig. 3, the farmers with capacity for fewest layers utilized more of their building space than did the larger producers. The poultry industry in this county could be increased approximately 40 percent by using existing laying house facilities to full capacity.

MARKETING POULTRY MEAT AND EGGS

Methods of Marketing[5]—Farmers in Emmet County marketed their poultry meat in several ways. One-fifth of them raised only enough chickens for home use. More than one-third sold their birds alive and an equal number sold freshly dressed birds. Only 1.4 percent sold some quick-frozen poultry (Table 1).

[5]This section reports the percentage of farms, not percentage of volume. Volume figures were not obtained; however, the authors believe that the percentage of farms is also indicative of product volume for each question asked.

TABLE 1—Poultry meat marketing methods

Method of sale	Percent of farms
Consumed on farm	21.4
Sold alive	34.3
Sold fresh dressed	34.3
Sold frozen	1.8
Not reported	8.6

Seasonal Sales—A majority of the broilers were sold during the summer months. Of some interest is the revelation that 70 percent of the farmers purchased "straight-run" chicks (mostly in March, April and May) and 70 percent of the broiler sales were in the summer. This indicates that those farmers who purchased straight-run chicks, sold their cockerels as broilers during this period.

Sale of hens was concentrated in the fall and winter months. Few farmers sold hens in the summer and very few sold in the spring as shown in Table 2.

TABLE 2—Seasonal variation in the sale of hens

Season	Percent of farmers selling hens
Spring	2.6
Summer	18.4
Fall	55.3
Winter	23.7

Marketing Channels Used—More than one-half of the farmers who replied sold their chickens directly to consumers. Thirty-seven percent sold to consumers who drove out to the farms, and 18.4 percent delivered poultry to the consumers in towns or cities. Thirty percent sold poultry to local grocers, and the remainder sold to eating establishments or at livestock auctions (Fig. 4).

Figure 5 shows that one-fourth of these farmers sold their eggs at the farm, whereas one-third delivered to consumers in town. The practice of delivering eggs into town was more important than that of delivering poultry meat. Since eggs are used as a daily food item, regular weekly deliveries should be more efficient than occasional deliveries of

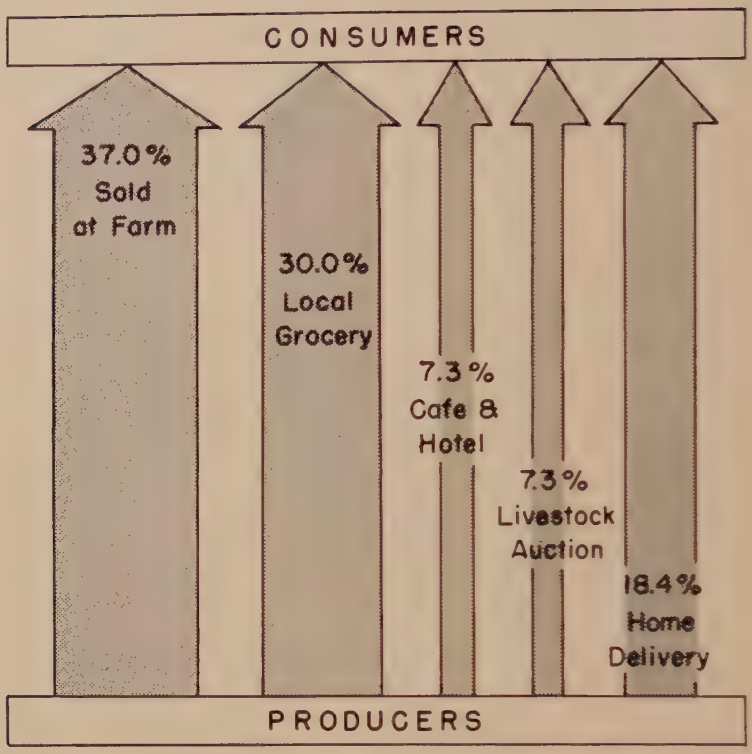

Fig. 4. Channels through which chickens moved from producers to consumers.

poultry meat. Thirty-five percent sold eggs to grocery stores, and only 6.6 percent sold to hotels and restaurants (Fig. 5).

Fig. 6 shows the relationship between egg production and retail egg prices. About one-third of the eggs were produced in the spring months when retail prices averaged 35 cents a dozen. As production declined, prices increased. Production reached a low in the fall when only 20 percent of the annual supply of eggs were produced. Retail prices during this period averaged 80 cents a dozen or more than twice the spring prices.

RETAIL OUTLET SURVEY

This survey was conducted through personal visits to 22 grocery stores, restaurants and hotels in Emmet County. At each establishment the same questions were asked the operators and their answers recorded for later analysis.

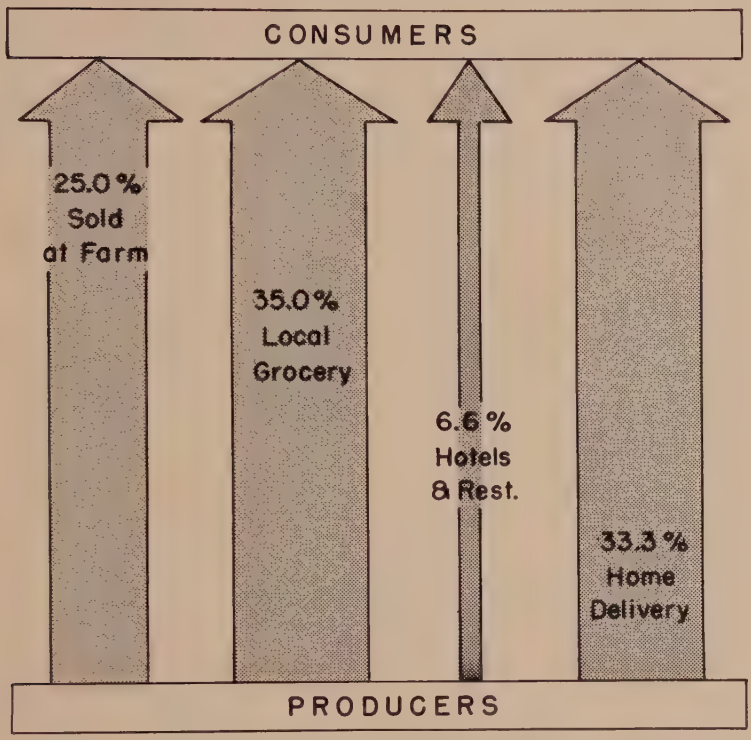

Fig. 5. Channels through which eggs moved from producers to consumers.

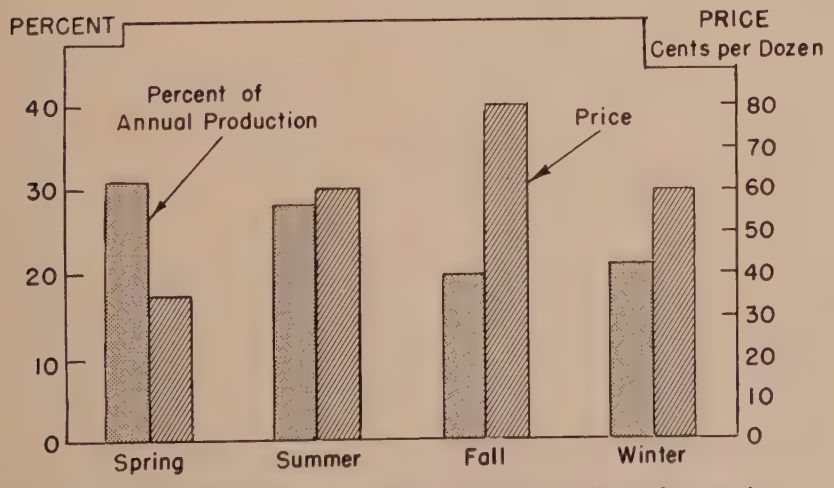

Fig. 6. Relationship between egg production and retail egg prices.

PROCUREMENT OF POULTRY MEAT AND EGGS

Source of Poultry Meat—The source of poultry meat varied with the size and type of establishment. The large super-markets purchased their poultry from commercial egg farms, from large meat packers, or from small meat packers. Restaurants and hotels purchased direct from farms (only if the farmers could supply their total requirements), or from meat packers. The small neighborhood grocers purchased from farmers or small meat packers.

Poultry Meat Preferences—White Rocks were the first choice of the poultry buyers and other "heavy" breeds were second choice. As indicated earlier, 41 percent of the farmers raised White Rocks for this demand. Broilers weighing 2½ pounds (oven-ready weight) were preferred and hens weighing 4 pounds were in greatest demand.

No live poultry was purchased by these firms. However, more than one-third purchased feather-dressed birds, whereas 60 percent purchased ready-to-cook poultry and 2 percent bought cut-up poultry. Practically no frozen poultry meat was purchased (Table 3).

TABLE 3—Poultry meat purchased by 22 stores hotels, restaurants and grocery

Poultry meat purchased	Percent of firms
Live poultry	0
Feather-dressed*	38
Ready-to-cook	60
Cut-up	2
Frozen	Less than 1

*New York-dressed or blood and feathers removed.

Egg Sales—As expected, more eggs were sold in the summer than any other season. Winter egg sales were lowest. This does not correspond closely to farm production in the county. Production reached a peak in the spring and a low in the fall (Fig. 7). This does not infer that the number of eggs produced in Emmet County during the spring, fall, and winter seasons was greater than consumption. It means that the seasons of high and low egg production do not correspond with the seasons of high and low egg consumption.

The local retail stores reported that they encountered several problems when local eggs were handled. Most of the farmers did not candle

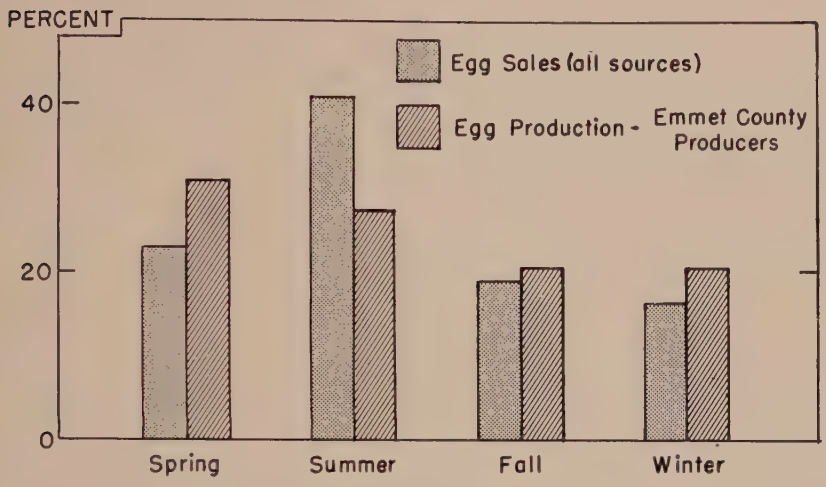

Fig. 7. Relationship between seasonal egg production and egg sales.

or grade their eggs, hence variations in size, cleanliness, and quality were evident. A number of complaints resulted from lack of quality. On the other hand, eggs from commercial sources which had been candled and sorted for size resulted in greater consumer satisfaction.

A Central Marketing Organization—Since one of the major purposes of this survey was to determine the desirability or need for a central marketing agency, each farmer was asked if he was in favor of such an organization. Over 80 percent of them indicated that they believed there was a need for both an egg and a poultry meat marketing organization.

A majority of the farmers who indicated no need for a marketing organization kept poultry for home use only. The remainder of them had fairly large flocks (250 or more hens) and sold directly to consumers.

More than 50 percent of the farmers indicated that they would increase the size of their flocks if a central marketing organization were available throughout the year. Three percent said they would support such an organization only during the non-resort seasons.

The retailers (grocerymen, hotel operators and restaurant managers) were asked whether they would purchase eggs and other poultry products from a local source if available. Every one of them answered in the affirmative. Some of them do purchase a part of their supply from local sources, but these retailers stated that they could not depend on a local source during the summer season.

A SOLUTION TO THE PROBLEM

The relatively small annual volume of egg and poultry meat production and the definite seasonal variation in demand because of the tourist trade make it impracticable to establish a poultry products marketing organization in this area of Michigan. Too often, when a marketing problem arises, the producers and local consumers turn to a proposed marketing organization to cure all of their ills. Unfortunately, it isn't that easy. A more realistic approach might be to consider and attempt to eliminate or minimize the fundamental cause of the problem.

A marketing organization is usually very beneficial in moving a perishable crop from a surplus production area to consuming centers. In the northern part of Michigan, particularly in and around Emmet County, there exists a situation of deficit production—not surplus production. In such a situation, farmers will (admittedly) sell to the tourist trade in the summer months and not to any marketing organization. These producers receive several cents more per unit for eggs and poultry sold direct to consumers than they could get from an organization which competes with the larger meat packers or national wholesale distributors.

Based on the survey data collected in Emmet County, it seems very logical and practical to approach the problem from an educational standpoint. Since total production of the county is less than total demand, this production should be geared to supply the poultry and eggs demanded during the resort season which, for the most part, coincides with highest prices. Although each farm may have individual problems a general recommendation can be given for the area. A suggested production program follows:

1. Purchase straight-run chicks in December or early January. Since the retailers preferred White Rocks first and other "heavy" breeds second, chick purchases should coincide with these preferences.

2. The males and cull pullets should be separated and dressed as either broilers or roasters to fit the local demand. If freezing facilities are available, they should be properly wrapped and quick-frozen for sale during the resort season.

3. Pullets can be removed to summer range and or laying shelters as soon as weather permits. They can remain there throughout the summer. These pullets should come into production in June and produce at a high rate during the resort season.

4. The brooder house can then be filled with broiler chicks which will be ready for the 2½-pound demand (stated preference by the retailers) when they are 10 to 12 weeks old.

5. The layers can be marketed in early winter before the December or January chicks are purchased. This would permit the farmer to use his laying houses for brooding early hatched chicks.

This program is only one of several that could easily be followed for greater net returns to the producers. Each farmer should analyze his own building facilities, equipment and time, and then plan his poultry program to best fit his own situation.

This type of a program should enable the local producers to take advantage of both the high egg prices and the high broiler prices. At the same time they would be supplying the market with good poultry products at a premium over the products shipped in from other areas.

INSOLATION: A PRIMARY FACTOR IN EVAPORATION FROM A FREE WATER SURFACE IN MICHIGAN

By GEORGE A. CRABB, JR.

Research Hydraulic Engineer, Soil Conservation Service, United States Department of Agriculture, in cooperation with Michigan Agricultural Experiment Station

Michigan is the only state east of the Mississippi having such scant rainfall as to be generally classed as "moist sub-humid" (19). Because of this scarcity of rainfall and the state's large acreage of high-return crops, the use of supplemental irrigation has increased markedly in the past few years.

Irrigation engineers, particularly, should be familiar with the rainfall of an area and evaporation to be expected. However, it is more difficult to obtain accurate evaporation figures than precipitation data. Evaporation rates are generally believed to depend upon so many different elements that they can be treated only in the most general manner. These elements include soil cover, soil treatment, temperature, humidity, insolation, wind movement, and saturation deficit of atmospheric water vapor. Most studies have tended to consider wind movement and saturation deficit as the two principal factors promoting evaporation. Rohwer (18) and Millar (15) have presented highly significant correlations between evaporation and atmospheric conditions. However, results of the program of basic research in soil and water conservation conducted by The Michigan Hydrologic Research Station[1] indicate that, although other atmospheric conditions are important factors in determining evaporation rates, insolation patterns may provide the most practical single index of evaporation.

Workers in a number of fields have for some time been aware of the relationship between solar radiation and evaporation. As knowledge of pyrheliometry has spread and as the number of observation stations has increased, more opportunities to evaluate the relationship of evapo-

[1]The Michigan Hydrologic Research Station is a cooperative research project of the U. S. Department of Agriculture, Soil Conservation Service, and the Michigan Agricultural Experiment Station at East Lansing, Michigan.

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ration to its various component factors have been found. Pyrheliometry is the measurement of the receipt at the earth's surface of solar radiation, or insolation. Correlations by Briggs and Shantz (4), (5), (6), Angstrom (1), (2), and Haines (10) have clearly shown that evaporation from a free water surface is chiefly the product of these four factors: insolation, temperature, saturation deficit and wind movement. Prescott has shown (16) that when the saturation deficit is sufficiently high, evaporation from a free water surface tends to be limited by the net radiation falling on the water surface. He developed a regressive equation to illustrate this. Application of the equation shows that as the values for saturation deficit rise, an increasing proportion of evaporation is caused by insolation until, for sufficiently high values, evaporation is entirely the product of insolation.

Harding (12) has stated that "evaporation that may occur from a water surface is primarily dependent upon the amount of solar radiation received and retained." Formulae for the computation of evaporation which are based upon the transformation of solar energy have been applied by Cummings (9), Bowen (3), Richardson (17), and McEwen (14). Such formulae are generally involved, and utilize factors not usually available. The method is theoretically sound, but ordinarily impractical.

Careful study of Prescott's work led to the assumption by the author that in a region of slightly deficient rainfall, such as southern Michigan, the average saturation deficit would be consistently high enough for insolation to be a paramount indicator of evaporation rates from a free water surface. A study was instituted to correlate observed insolation values with evaporation losses, and test this assumption. It was quickly determined that day-to-day correlations of raw data covered too wide a range of variation for comparison. Accordingly, normal annual patterns for daily values of insolation and evaporation were developed. These patterns were graphically compared (Fig. 1), and show markedly close correlation. It is, therefore, felt that under certain circumstances normal patterns of insolation or evaporation may be developed one from the other, which will greatly facilitate the prediction of water needs of an area. The close correlation between the two patterns further substantiates the assumption that, under certain conditions, insolation is the primary indicator of evaporation rates from a free water surface.

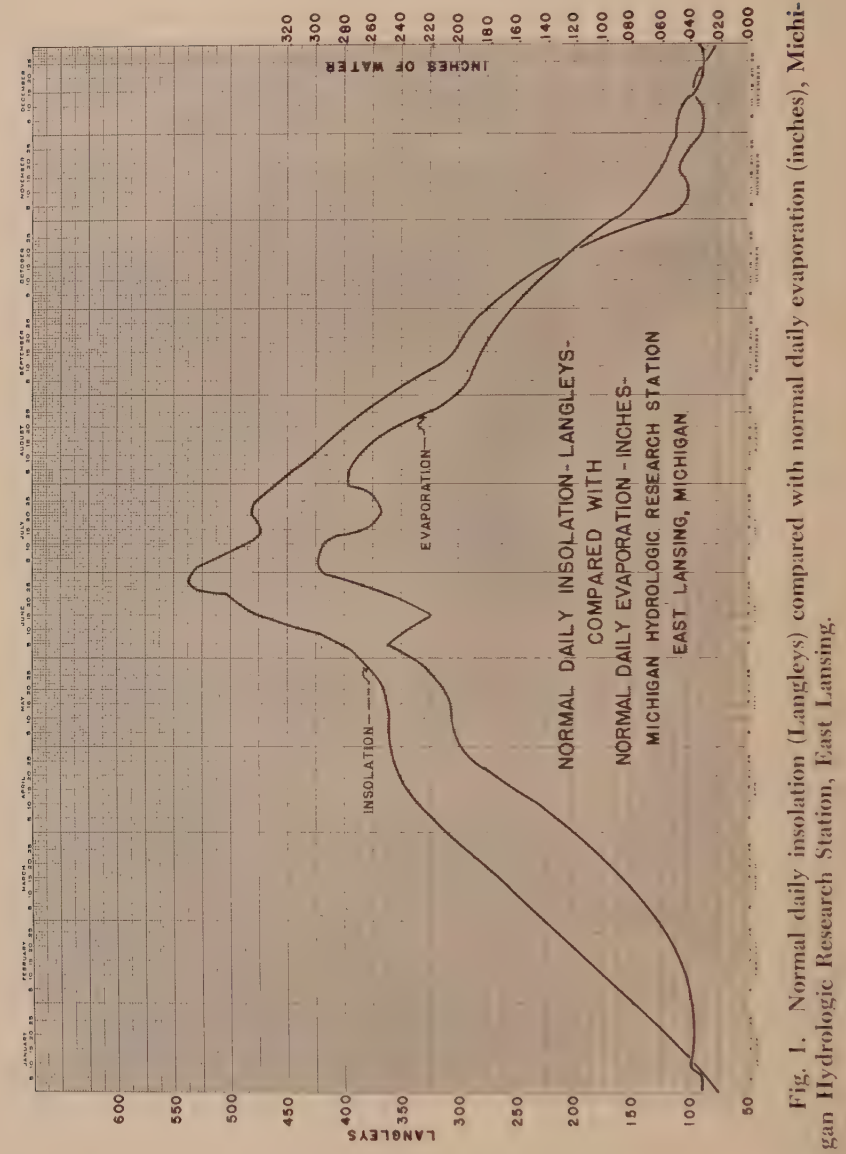

Fig. 1. Normal daily insolation (Langleys) compared with normal daily evaporation (inches), Michigan Hydrologic Research Station, East Lansing.

Daily rates of insolation and evaporation have been determined for the past several years at the Station's cultivated watersheds near East Lansing. Insolation is measured by means of an Eppley pyrheliometer, the output of which is recorded by a Leeds and Northrup automatic recording potentiometer. Planimetric analysis of the trace by standard procedure (11) gives hourly values of insolation in Langleys (gram-calories of energy per square centimeter).

Evaporation losses from a free water surface are determined by means of a "black-pan evaporimeter" which measures the actual water losses from a surface 4 feet above ground-level. This instrument, which is not in general use, deserves more than cursory description. The unit consists of a shallow black pan mounted on and replacing the catchment mechanism of a Fergusson-type, 9-inch, weighing, recording raingage. Water is kept in this pan at all times, being regularly replenished when reduced by evaporation or sublimation. The evaporimeter is located immediately adjacent to a standard raingage, so that replenishment by precipitation can be correctly accounted for. No correction is made for condensation. The surface area of the evaporimeter pan is painted a dull black to bring about the maximum absorption of insolation, and the maximum rate of evaporation to be expected. The pan has an area equal to 10 times the catchment area of the 9-inch raingage, permitting an accurate reading to 0.001 inch.

Evaporation losses at other stations are generally determined with either a Weather Bureau, Bureau of Plant Industry, or Colorado-type pan. These pans all utilize a different principle in determining evaporation losses from that of the evaporimeter in use at East Lansing. Whereas the evaporimeter automatically records water losses by means of variation in the weight of the filled pan, conventional gages require daily determination of water levels with a hook-gage. Such pans must of necessity operate only under frost-free conditions, but the weighing mechanism of the evaporimeter maintains an accurate record regardless of temperature, permitting evaporation and sublimation records to be obtained on a year-around basis. Each of the three conventional type pans is partially sunk in the ground, or mounted just above ground level, while the evaporimeter is installed 4 feet above ground surface. Occasionally, evaporation measurements are made with pans of one of the above-mentioned types floated in the surface of a lake or other body of water. In order to permit correlation of the data from East Lansing with that from stations using more conventional equipment, a standard Weather Bureau type pan was installed adjacent to the evaporimeter in 1951. Preliminary results indicate that the evaporation losses as measured by standard equipment averaged only 89 percent of evaporation losses determined by the evaporimeter (Table 1). This is probably accounted for by one or both of two major differences between the two instruments: 1) A 4-foot difference in elevation of the

exposed water surface, and 2) the fact that the evaporimeter pan is blackened for maximum heat absorption, whereas the Weather Bureau pan has a natural galvanized finish.

TABLE 1—Comparison of normal monthly totals of evaporation from evaporimeter with 1951 monthly totals from evaporimeter and U. S. Weather Bureau class A evaporation pan

Month	Normal evaporation	1951 Class A evaporation	1951 Evaporimeter evaporation
	(*inches*)	(*inches*)*	(*inches*)
January	1.06	....	0.75
February	1.26	....	0.86
March	2.69	....	2.41
April	4.83	....	3.27
May	6.51	6.14	6.74
June	7.36	5.25	5.82
July	8.50	7.09	7.39
August	7.67	5.76	6.84
September	5.41	4.79	5.29
October	4.08	2.95	3.55
November	1.93	....	1.37
December	1.12	....	0.98
Total—Annual	52.42	....	45.27
Total—May-October	39.53	31.98	35.63

*Record available only for frost-free months.

In order to develop a normal annual curve of daily values of insolation, the daily insolation values were plotted for several years (8). However, the resulting curves, because of the wide range of daily fluctuation, proved almost impossible to evaluate. Conventional methods of smoothing the curve proved inadequate because of the extreme distortion which resulted from their application. Accordingly, a compound method of smoothing the data was developed, tested statistically and graphically, and applied. This method consisted of preparing a 15-day moving average of the consecutive daily values for a 5-year array of data, and then preparing an arithmetic average for each of the daily values resulting therefrom. The resulting "normal" array of daily values for an average year gave an exceptionally smooth spread of data. This was further refined, in plotting, by fitting a smooth curve, by eye, to the pin-pointed values (7). The graphic presentation showed the normal pattern of daily insolation at East Lansing, with daily values very comparable to those actually received.

In preparing a normal annual curve of daily values for evaporation losses from a free water surface at East Lansing, essentially the same method of development and presentation was used. A 15-day moving average of six-years' consecutive data was prepared. Arithmetic averages of the daily values resulting were made. The values were plotted, and a smooth curve fitted by eye. The resulting curve, when plotted opposite the normal curve for insolation, showed markedly close correlation, amply demonstrating that, under East Lansing conditions, insolation is a primary indicator of evaporation losses from a free water surface. It is of particular interest to note that the spring "plateau," which so markedly differentiates the East Lansing pattern of insolation from other pyrheliometric patterns (8), is also apparent in the normal pattern of evaporation at East Lansing. Exaggerations of the other characteristic peaks and valleys of that pattern of insolation are apparent to a less degree.

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OBSERVATIONS ON PACKAGE BEES IN 1951

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PART I. DATES FOR INSTALLING PACKAGE BEES

The shipment of package bees from southern shippers to northern beekeepers has been a well established business for many years. In 1951, the 290,000 packages of bees shipped from the South to apiarists in the North represented, however, a reduction in numbers from recent years. In Michigan, packages are used predominantly to replace winter losses and to start new colonies.

Kelty,[1] following extensive tests, showed that in Michigan a package of bees requires about 10 weeks to build up to adequate honey-gathering strength. In the northern great plains area it is popularly stated that package colonies will build up to adequate honey-gathering strength in 8 weeks. Those statements do not necessarily conflict as weather factors, such as comparative amounts of solar radiation, may cause variation in the egg-laying and brood-rearing activity in different areas.

In order to allow a 10-week build-up period, package bees should be installed in Michigan during the first few days of April, as the main honey flow normally begins about mid-June. Technical and popular publications usually advise beekeepers to hive packages sufficiently early to allow a 10-week build-up period. This advice implies that packages should be hived about April 1 in most of the Lower Peninsula of Michigan. Experience has shown that package bees can be safely installed in Michigan at that date provided they are placed in hives containing drawn combs with honey and pollen. Literature in which arrival dates for package bees have been recommended has not distinguished between the beekeeper who has available drawn combs with honey and pollen and the one who does not have this advantage. Many

[1]Kelty, R. H. Observations on the Performance of Package Bee Colonies in Michigan. Mich. Agr. Expt. Sta. Spec. Bul. 344. 1948.

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packages are hived every year, particularly by beginners on comb foundation. A syrup made of white sugar dissolved in water is supplied to feed the bees. Because packages hived in this way are quite perishable in cold weather it was considered desirable to observe the development of such packages when hived on different dates, to see if more specific recommendations might be formulated.

EXPERIMENTAL PROCEDURE

Packages were installed in hives on comb foundation. All packages were fed sugar syrup in feeder pails which were placed above the combs and also cakes of pollen substitute made from soybean flour and brewers yeast.

Packages were hived at East Lansing on the following dates: April 4—2 packages; April 10—10 packages; April 13—12 packages; and May 7—14 packages.

Progress of the colonies was recorded as follows:

Packages Hived April 4—The average of the maximum temperatures for the six-day period following the hiving of those two packages was 58.1° F. If the temperature inside a hive drops below 57° F. honey bees cluster together in order to maintain temperature. The temperature was, however, sufficiently high for sufficiently long periods of time to allow those two colonies to break cluster so that they could build comb, store food and survive satisfactorily.

Packages Hived April 10—Weather following this date was cold, with strong winds, cloud cover and traces of snow. Average maximum temperature for the 6 days following hiving was 45° F., and the highest temperature recorded during that time was 56° F. At the end of 6 days five of the colonies were dead and all were weakened.

Packages Hived April 13—Weather following the installing of those packages continued cold, windy and cloudy. There was no sunshine or warm spell, so the bees did not have an adequate opportunity to break cluster in order to feed themselves. Average maximum temperature for the 6 days following hiving was 45.1° F. The highest recorded temperature during that period was 52° F. Five of those colonies died and all were weakened.

Packages Hived May 7—The average maximum temperature for six days following the installing of those packages was 61.1° F. No colonies were lost through cold, and their development was satisfactory.

CONCLUSIONS AND RECOMMENDATIONS (PART I)

1. Beekeepers are commonly advised to purchase package bees 10 weeks before the main honey flow in Michigan and nearby states. Following this rule, packages would have to be hived about April 1 in most parts of the Lower Peninsula of Michigan.

2. This date has proven satisfactory for packages hived on drawn comb containing honey and pollen.

3. Many beekeepers, particularly beginners, do not have drawn combs and must install packages on comb foundation.

4. Out of 22 experimental packages installed on comb foundation during the first half of April in 1951, 10 died and the others were weakened.

5. Weather data, as reported by Baten and Eichmeier,[2] indicates that a period of weather in early April similar to that experienced in 1951 might be considered fairly normal for Michigan.

6. The possibility of loss from cold is made greater by the fact that the low amount of solar radiation normal during April in Michigan does not assist the bees to warm the hive and break cluster in order to build comb and store food.

7. The fact that two packages which were hived on April 4 lived and thrived indicates that a few days of warm weather will allow package colonies to survive. Such packages which do survive have time to build up to strong, populous colonies in time for the main honey flow.

8. The chance of losing all or some packages hived on foundation in Michigan prior to April 20 is great. It is considered that the chance of loss offsets the desirability of early purchase.

9. Advice to purchasers of package bees with regard to hiving dates should specifically differentiate between packages installed on drawn combs containing honey, and packages installed on foundation. This is particularly pertinent because of the early spring weather conditions characteristic of Michigan.

10. The results suggest that package bees be installed on comb foundation in Michigan from April 20 to April 30, with beekeepers in the colder areas choosing the latter part of this period. This will sacrifice some of the 10-week build-up period but will largely eliminate the danger of severe losses inherent in the earlier arrival of bees.

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[2]Baten, W. D. and Eichmeier, A. H. A summary of Weather Conditions at East Lansing, Michigan prior to 1950. Mich. Agr. Expt. Sta. (unnumbered pub.) December 1951.

PART II. A COMPARISON OF TWO-POUND VS. THREE-POUND PACKAGES HIVED ON COMB FOUNDATION

Many comparisons of the value of 2- and 3-pound packages of honey bees have been made in experimental and commercial apiaries. No record can be found specifying that comparisons were made when the packages were installed on comb foundation, rather than on drawn comb. In general, tests have indicated that 3-pound packages have no advantage over 2-pound packages unless the packages were hived considerably later than the recommended dates. This is because the bees which come in the package die off in a few weeks. The function of the bees in the package is to rear enough brood so that the colony may carry on and increase steadily in strength after the original bees have died.

When packages are installed on foundation a new factor becomes involved: the requirement of the bees from the package to produce wax and build comb in order to make cells available for rearing brood or storing food. It was felt that this factor might favor the use of 3-pound packages. In view of the fact that a new package bee apiary was to be developed at Michigan State College, on comb foundation, it was decided to purchase an equal number of 2-pound and 3-pound packages for this comparison.

Twelve 2-pound packages and 12 3-pound packages were installed on comb foundation and observed throughout the 1951 season. Packages compared were hived on the following dates:

Date	*3 lb. Packages*	*2 lb. Packages*
April 4	1	1
April 10	2	2
April 13	3	2
May 7	6	7

TABLE 1—Comparative production of drawn comb, brood and honey by 2-pound vs. 3-pound packages

	Combs of foundation drawn by June 25		Combs containing brood on June 25		Pounds of honey produced by August 10	
	Total	Average	Total	Average	Total	Average
12 2-lb. packages.	158	13.1	114	9.5	960	80.0
12 3-lb. packages.	183	15.2	115	9.5	1050	87.5

DISCUSSION

In these tests, 3-pound packages built comb more rapidly and stored an average of 7.5 pounds more honey than 2-pound packages. Each group averaged approximately the same amount of brood by June 25. The fact that brood count was similar indicates that a good queen can offset the value of an extra pound of bees in the package. The extra 7.5 pounds of honey obtained in this test from colonies derived from 3-pound packages would not pay for the extra cost of 3-pound packages.

These comparisons are being recorded, not as conclusive evidence on the best type of package, but in order to supplement various other tests which have been made throughout the country.

EFFICIENT MILK CAN CONVEYOR DESIGN FOR DAIRY PLANTS

By CARL W. HALL
DEPARTMENT OF AGRICULTURAL ENGINEERING

MICHIGAN PRODUCED 5,677,000,000 pounds of milk in 1949.[1] About 40 percent of this milk was processed and sold as fluid milk by 846 milk dealers. During the 15-year period, 1935 to 1950, the mortality of dairy plants has been about 50 percent. This fact illustrates the importance of making a complete analysis of the problems involved in the efficient operation of dairy plants. One of the common causes of the loss in efficiency in the operation of a plant is an incorrectly designed milk can conveyor.

OBJECTIVE

A study was made with the objective of analyzing the operations involved in the functioning of the conveyor and making recommendations for more efficient design and use of the can conveyor.

PROCEDURE

The receiving rooms of nine dairy plants in southern Michigan were studied from the standpoint of the efficiency of use of labor and equipment. Time studies were made of each operation in the receiving room and standard times were established on the basis of those studies. These time studies, together with observations, pointed out inefficient practices and arrangements.

The length of the conveyor varied greatly in different plants. An analysis of the optimum length of conveyor was carried out and is summarized in Fig. 1. The results are based on receiving a 100-can truck load, with the trucker unloading cans and loosening lids at the rate of seven cans a minute. Two minutes were allowed to move the truck to the empty can conveyor from the unloading position. A conveyor

[1]Dairy Industries Catalog. Olsen Publishing Company. Milwaukee, 1951, p. 46.

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speed of 15 cans a minute was assumed. The total length of conveyor, which is represented by the numbers in Fig. 1, was obtained by adding the incoming conveyor length to the outgoing empty can conveyor length necessary, so that the dumping rate was not slowed down because of an accumulation of empty cans on the conveyor.

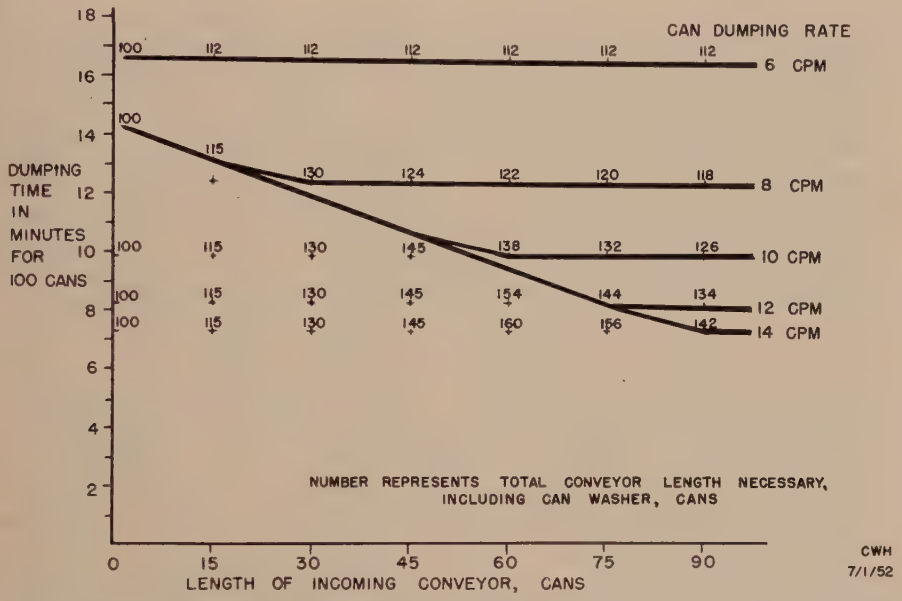

Fig. 1. Relationship of dumping time and conveyor length for different lengths of incoming conveyor and different dumping rates.

RESULTS

The design of the conveyor equipment will often limit the efficiency of the other operations in the receiving room.

In most plants where both gravity and power conveyors were used, the cans would lodge at the junction of the two conveyors. The conveyors should be located on the same level or slightly above the truck bed to facilitate unloading. The empty can conveyor should be close to the dump position, if the dumper is checking for quality, so that only a short reject line is required.

In some plants considerable difficulty was encountered from the cans pinching at the dump. The least difficulty was observed when the cans were dumped at a right angle to the conveyor. When the cans were dumped in the direction of the conveyor travel, the cans would pinch into the dump, causing unnecessary delay at the dumping

operation. A good arrangement to prevent pinching of the cans at the dump is shown in Fig. 2.

The truck loading position at the end of the outgoing conveyor should be close to the unloading position of the incoming conveyor, but there should be sufficient area for one truck to be unloading and

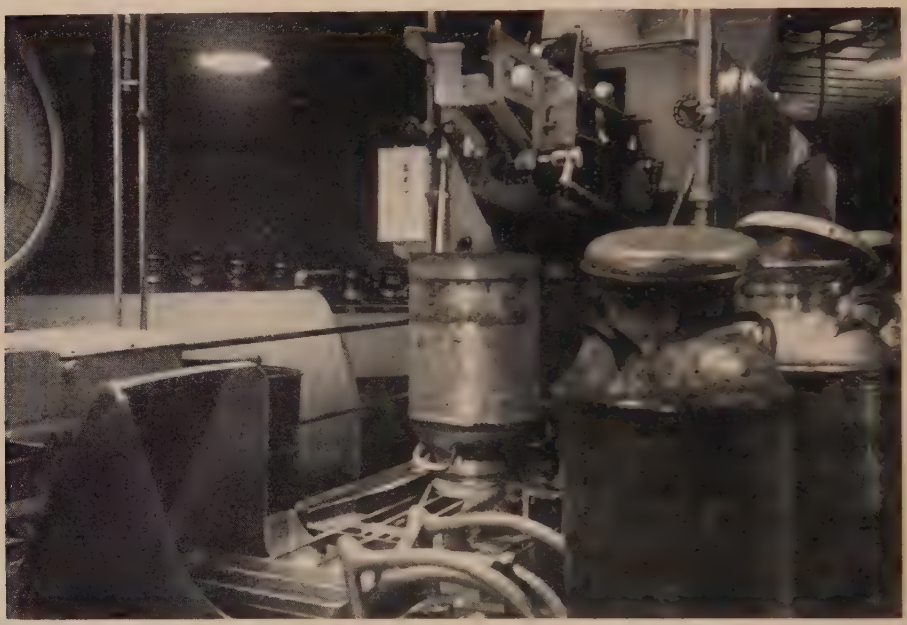

Fig. 2. Cans dumped at a right angle to the conveyor.

another one to be loading at the same time. In large operations the possibility of having two incoming conveyors—so that two trucks could be unloaded simultaneously—should be investigated. In the plant the conveyors should be arranged so that the workmen are not "boxed in."

Less delay in the receiving room was noted when there was a conveyor control for the truck driver near the unloading platform. This was particularly true when the farm milk trucks did not arrive on schedule.

A very important relationship exists between the conveyor length and the dumping time. For a dumping rate of six cans a minute, the dumping time is the same, regardless of the length of incoming conveyor (Fig. 1). When the dumping rate is slower than the speed at which the trucker can unload, there is no advantage to a long incoming conveyor. A trucker can unload cans and unloosen lids at a rate of

seven cans a minute. The length of incoming conveyor is usually from 30 to 40 feet. Where the dumping rates are faster than the rate at which cans are placed on the conveyor, the dumping time is affected by the length of incoming conveyor. For example, for a dumping rate of eight cans a minute, the dumping time is reduced from 14.3 to 12.5 minutes for 100 cans, as the conveyor length is increased from zero to 30 feet (Fig. 1). When the incoming conveyor is 30 feet long, a total conveyor length of 130 feet is required (Fig. 1). As the length of the incoming conveyor is increased from 30 to 90 feet, the time required for dumping does not change, but the total length of conveyor required decreases from 130 to 118 feet (Fig. 1). What is the explanation for this relationship? As the length of incoming conveyor is increased, the number of cans remaining for the trucker to unload from the truck is decreased; thus the trucker can unload the cans, move the truck to the empty can conveyor, and remove cans from the empty can conveyor sooner than if a short incoming conveyor is used.

In a large operation, with more than one man in the receiving room and when the trucks arrive at the plant on a schedule so as to prevent receiving room delays, the trucker can unload the cans without loosening lids at a rate of 10 cans per minute. Another trucker can loosen the lids. In most receiving operations, a rate of 10 cans per minute is fast enough to keep the dumper supplied with cans. If the truckers cannot or do not help each other unload, a double incoming conveyor could be constructed with a Y-feed at the dump. Two trucks could then unload at the same time, although the dumper would take only one load at a time. Such a procedure would require long incoming conveyors.

Long empty can conveyors often require the truck driver to wait an excessive length of time for the empty cans for small loads. This is often of particular importance in the spring when the truck driver may have half loads because of highway load regulations in Michigan. A long empty can conveyor, 120 feet in length, may require 8 minutes for the cans to travel its length. To speed can delivery to the truck, truck drivers will often lift the cans over one of the conveyor loops so that the can will travel only one-half of the empty can conveyor length. A cross-over could be designed into the system to facilitate the movement of the cans.

SUMMARY

One man cannot conveniently unload cans from the truck and loosen lids rapidly enough to supply a dumper at a rate above seven cans a minute. The connections between gravity and roller conveyors should be carefully designed to prevent lodging of cans and periodically inspected. The incoming conveyor should be level with the bed of the truck or slightly higher. The conveyor should be arranged so that the cans are dumped at a right angle to the conveyor. This will prevent the cans from "pinching" while dumping. The incoming and outgoing conveyors should be arranged so that only a short reject line is required and, also, with sufficient room for one truck to be unloading as another truck is loading. The length of the incoming conveyor has an important relationship with the dumping time, especially for dumping operations which occur at a speed above seven cans a minute. In some cases, by making the incoming conveyor longer, it is possible to decrease substantially the total length of conveyor required for the operation. Each dairy plant superintendent should investigate the possibility of increasing his efficiency with a properly designed conveyor.

MEETING LOW-OVERRUN ICE CREAM COMPETITION

By P. S. LUCAS and M. P. LANKFORD
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DURING THE postwar years considerable change has been made in the body and texture of ice cream, the trend being very marked in the public preference for a heavier type. This type of body, also, has been characterized as "chewy" or caramel-like. Some of this preference has been created by the public's belief that such ice cream contains less overrun than the lighter, more fluffy, or brittle-bodied ice cream. This has led to a demand for hand-dipped ice cream on the assumption that, in the process of packing, much of the air is pressed out of the ice cream and that the buyer, although paying more for the product, is receiving more per unit paid for. Hand-dipped ice cream is more "chewy" or caramel-like in body. In the postwar merchandising of ice cream many of the chain stores, and other stores as well, have specified ice cream which has a definite weight per package, so they can merchandise a product to compete with hand-dipped ice cream. This is a very practical procedure except for one thing: When ice cream is sold by weight, a premium is placed on ice cream containing maximum amounts of products such as sugar and skimmilk solids which are high in specific gravity and usually low in price. Because butterfat is low in specific gravity, an increase of the amount of it in ice cream lowers the weight of the cream.

In an effort to meet the competition of the hand-dipped package, ice cream has been manufactured and sold with as low overrun as 45-65 percent. If drawn from the freezer at this overrun, much of the labor of hand dipping and serving is saved. The difficulty in dipping is serious since the operation is lengthy and laborious and is irritating to customers waiting for their packages. The mere fact that ice cream is hand dipped does not mean that all of the overrun is removed. The inexperienced dipper of such ice cream, however, will remove the

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overrun down to around 40 percent, thus dipping only about 13 or 14 quarts out of 20 quarts of bulk product. On the other hand, it is very difficult to draw from a commercial freezer ice cream containing 40 percent overrun without the mix being so wet and incompletely frozen that it becomes somewhat coarse and icy in the hardening room.

Some judges of ice cream refer to "chewy" body as gummy or heavy. It would seem inconsistent to criticize such ice cream as being heavy when a considerable portion of the public prefers this heavy product and is willing to pay for it, believing that they get more for their money, which, in most instances, is a correct assumption.

Various factors have been named by manufacturers as causing ice cream to seem "chewy", the more likely assumptions being the amount of solids incorporated, kind of stabilizer used, or type of sugar used. It is generally believed that the milk-solids-not-fat content could well be increased from 8 to 11 percent, or more, and thus make the ice cream somewhat better nutritionally by narrowing the ratio of fats and carbohydrates to protein. The authors believed that the three factors mentioned above were the ones that should be investigated.

EFFECT OF VARIED MILK-SOLIDS-NOT-FAT UPON OPTIMUM OVERRUN

In a series of freezings, 12 percent-fat ice creams were made, containing 8, 10, 11, 12 and 14 percent milk-solids-not-fat. These batches of ice cream contained 10.5 percent of cane or beet sugar and an additional 2.25 percent Sweetose and 2.25 percent dextrose, making the total sugar equivalent 15 percent, which is standard for this state. The amount of dextrose required was, therefore, 2.71 pounds per hundredweight of mix, and, of Sweetose 3.36 pounds. The sweetening values used throughout this work were sucrose 100 percent, corn syrup solids 49 percent, Super Sweet Syrup 50 percent, dextrose 83 percent, Sweetose 67 percent, and Puritose 50 percent. The less sweet the substitute sugar the greater the amount required for the replacement and, therefore, the greater the total solids in the ice cream.

The samples which scored highest were those containing 11 or 14 percent of milk-solids-not-fat. Those containing 14 percent milk-solids-not-fat, when held for a few weeks, as is well known, develop the very serious defect of "sandiness." In no instance was a sample containing from 40 to 49 percent of overrun selected as most desirable, but one containing between 70 to 79 percent seemed better for serving as com-

mercial ice cream. It was noted that samples containing from 40 to 49 percent, upon hardening, were practically impossible to cut into servings because of the excessive solidity. High-solids samples had a marked milk powder flavor, were very solid, showed various degrees of "sandiness", and appeared less cohesive than the 11-percent serum solids. The effect of milk-solids-not-fat could not be considered great in producing the desired, well-knit-together, "chewy", cohesive-bodied ice cream.

EFFECT OF VARIOUS COMMERCIAL STABILIZERS ON SCORE AND OPTIMUM OVERRUN

In a second series of mixes frozen, all were made up to contain 12 percent fat, 11 percent milk-solids-not-fat, and 15 percent sugar equivalent. Thirty percent of the sucrose was replaced by the other sweeteners mentioned. Fifteen percent of the replaced sugar was supplied by dextrose, and the other 15 percent was replaced by Sweetose. Each mix, however, contained a different stabilizer. The stabilizers used were as follows: one contained 275 Bloom gelatin; another, Vesterine (⅔ gelatin and ⅓ mono- and di-glycerides); a third, carboxymethycellulose; another, Dariloid; another, Polycoid; still another, pectin; one, Krageleen; and last, Gelox. With the second, fourth, fifth, seventh, and eighth stabilizers, the optimum overrun was 50-59 percent. With the third, the choice lay between 60 to 69 percent, and with the first and sixth it lay between 70 to 79 percent. The highest score given was with the first, and this was but 1.25 above some of the others. Gelatin alone affected the body to such an extent that its highest score was noted at 70-79 percent overrun. No other stabilizer equalled this performance, although Vesterine was close. Optimum scores for most occurred in the 50-59 percent column. All except two, however, had good scores at 70-79 percent overrun. No stabilizer tried produced a cohesive, "chewy" body at 80-89 percent overrun.

EFFECT OF PERCENTAGE OF SWEETENER

In most of the tests, the sugar equivalent was 15 percent; i.e., 15 pounds sucrose per 100 pounds mix. In a second series, the sugar was cut to 12 percent, and 30 percent of the sucrose value was replaced by other sugars. Those used in replacement were dextrose, corn syrup solids, Sweetose, Super Sweet Syrup, and Puritose. The other sugars used had little effect, if any, upon the results. Lowering of the sugar content to 12 percent lowered the scores of the ice creams appearing

in the 60 to 69-percent overrun group under those appearing in the same group with 15-percent sugar equivalent. This was to be expected since total solids were correspondingly lowered. In the meltdown tests where corn syrup solids were used, it, of all the sweeteners, caused the greatest amount of melting at all percentages of overrun, and the second greatest was caused by a product known commercially as Puritose.

TABLE 1—Optimum overrun with various sweeteners used in conjunction with sucrose, 12 percent sugar equivalent

Sweeteners	Scores at various overruns*							
	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119
Sucrose	27.75	28.00	*28.5*	28.25	28.00	27.50	27.25	.....
Dextrose	28.12	28.75	*29.25*	.....	29.00	28.75	27.50	.....
Corn syrup solids	28.00	28.12	*29.0*	28.75	28.50	28.25	.....	.....
Sweetose	28.50	*29.0*	28.25	17.62	.....	.....	.....	27.00
Super sweet syrup	27.25	27.75	28.25	*28.50*	27.75	.....	27.25	.....
Puritose	27.62	.....	28.25	.....	*28.50*	.....	27.37	.....

*Maximum score is underlined.

EFFECT OF VARIOUS SWEETENERS ON ICE CREAM SCORES

When the several supplementary sweeteners were used in conjunction with a 15-percent sugar equivalent, their effects, except for one, were so devoid of notable differences that they can be said to have little effect upon cohesiveness in ice cream. This replacement with the substitute sugar was again 30 percent of the sucrose. In all instances, except that of corn syrup solids, the highest score was placed on samples containing 60-69 percent overrun. With corn syrup solids, the optimum overrun appeared to be 80-89 percent. As with the 12-percent sugar equivalent, the use of corn syrup solids gave much the largest amount of meltdown, with Puritose syrup being a poor second.

The outstanding variation occurred in ice cream containing 30 percent sucrose replacement with corn syrup solids. This exhibited such a "chewy" characteristic that its optimum score was obtained at 80-89 and 90-99 percent overrun. This effect gave this cream the qualities found more frequently in low-overrun and hand-dipped ice creams. Ice cream containing all other sugars reached their

TABLE 2—Optimum overrun with various sweeteners used in conjunction with sucrose 15 percent sugar equivalent

Sweeteners	Scores at various overruns*							
	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
Sucrose.....	28.50	28.75	28.62	*29.75*	.....	29.50	.....	29.00
Dextrose.....	.....	28.25	29.00	*29.50*	28.75	.....	28.50	.....
Corn syrup solids..	.....	29.00	29.25	29.50	.....	*29.75*	*29.75*	.....
Sweetose.....	.....	*29.00*	*29.00*	*29.00*	28.00	.....	28.50	.....
Super sweet syrup.	28.50	28.75	29.00	*29.25*	28.50	.....	28.00	27.75
Puritose.....	27.75	28.00	28.62	*29.25*	.....	28.50	.....	27.50

*Maximum score value is underlined.

maximum score at overruns of 60-69 percent. Economically, this may mean a great deal to users of corn syrup solids by thus permitting the incorporation of greater overrun as well as the production of the tougher, "chewier" bodied ice cream, while retaining the qualities of a low overrun. That observation merited further trials of this interesting sugar.

VARYING MILK SOLIDS WITH PARTIAL REPLACEMENT OF SUGAR WITH CORN SYRUP SOLIDS

The preceding trials indicated that corn syrup solids, used as a partial sugar replacement, produced ice creams which were more caramel-like in body and had no effect on taste other than imparting a slight syrupy flavor. When mixes were made containing enough sugar to give approximately a 15-percent sugar equivalent, 30 percent of the sucrose that would normally be used was replaced by corn syrup solids. Replacement of 30 percent of the sucrose would mean reducing its amount to 10.5 percent and, assuming corn syrup solids to be 50 percent sweet, replacing this 4½ pounds of sucrose with 9 pounds of corn syrup solids. This was done, and mixes were made with the milk-solids-not-fat content varied in amounts of 8, 10, 12, and 14 percent. The fat in all cases was held at 12 percent and the stabilizer, Vesterine, to 0.35 of 1 percent. The results are given in Table 3.

When this partial replacement of sucrose was made with corn syrup solids, except for the group containing 14 percent of milk-solids-not-fat, the optimum overrun lay between 70-79 percent (Table 3). Obviously the first observation with corn syrup solids was too optimistic, the

TABLE 3—Optimum overrun with varied milk-solids-not-fat. Mix 12 percent fat, 10.5 percent sucrose, and 4.5 percent corn syrup solids (equivalent)

M. S. N. F. content, in percent	Scores at various overruns*								
	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119
8.....	.....	28.00	28.37	28.75	*29.00*	.....	28.00	.....	27.00
10.....	.....	28.50	28.75	.....	*29.37*	28.00	.....	27.75	27.25
12.....	.....	28.25	29.00	.....	*29.50*	.....	28.50	27.75	.....
14.....	.....	28.25	.....	28.75	*29.50*	*29.50*	.....	29.00	.....

*Maximum score value is underlined.

optimum lying in the 70-79 percent overrun group rather than in the 80-89 percent group. This optimum group, however, was still higher than for the other sugars so far as cohesiveness was concerned, and the results, while not so spectacular, were important. Ice cream containing 8 percent milk-solids-not-fat, although satisfactory, was not so desirable as the other groups on account of its lack of solids. The 14 percent milk-solids-not-fat group scored well, was smooth, "chewy", but was criticized as being too heavy and having too much of a powdered milk taste. The 10-12 percent milk-solids-not-fat groups were excellent so far as body was concerned, especially for those ice cream manufacturers who are striving to produce this type of body in their ice cream. In processing, however, it was found that the replacement of 30 percent of sucrose with corn syrup solids may produce some difficulties in mix handling, as in pumping the mix any distance. The viscosity produced was high. When 20 percent of sucrose was replaced with corn syrup solids a satisfactory mix, from the viewpoint of this difficulty, was produced without loss of cohesiveness to any marked degree. If "chewy" ice cream is the type body which the manufacturer is seeking, it may be produced by the use of corn syrup solids and the higher cost of the sweetening units will be more than compensated for by the amount of overrun that may be taken. A survey shows that the manufacturers of this state favor this type of ice cream body, and observation shows that the consumer prefers it. The ice cream does not break apart so readily, has better dipping qualities, and consumers do not object to the slight syrupy taste.

Corn syrup solids ice creams melt a trifle more rapidly than those sweetened entirely with sucrose, but their melting point is so little increased that they may be held in the cabinet at about the same temperature as other ice creams.

EFFECT OF MALEIC HYDRAZIDE ON THE THINNING OF PEACHES DURING THREE SUCCESSIVE YEARS

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CONSIDERABLE WORK has been done with various chemical compounds for thinning fruit crops. During three successive years, 1950-52, maleic hydrazide was studied to determine its effectiveness in thinning peaches. Thinning is frequently required to assure fruit of high quality with a diameter of 2½ inches or more.

Other materials—sodium thiozale, sulfhydryl compound, and naphthaleneacetic acid—were also investigated during the 1950 season. Only maleic hydrazide showed promise that year, and the use of the other three compounds was discontinued.

Mature trees in a commercial orchard were used in the experiment. Several limbs of each tree were carefully chosen for uniformity as to size, position on the tree, age, and physiological health and vigor. Spray applications were confined to individual branches, on which the number of buds on each limb was recorded. Sprays were applied with a 3-gallon knapsack sprayer.

Soon after the normal June drop, the number of fruit that set and developed were counted and recorded. This count was rechecked several times during the growing season, and thorough observation was made for any irregularities in foliage, terminal growth and fruit maturity.

RESULTS

The results of the various applications were evaluated on the basis of observations which have indicated that a 10- to 15-percent set will provide a full crop of fruit for peach trees which bloom full.

The data (Tables 1, 2 and 3) show, in general, a definite reduction in set when maleic hydrazide was applied at a concentration of 500

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p. p. m. or greater during the bloom period. The degree of reduction was greatest at the highest concentrations. Satisfactory commercial thinning at 500 p. p. m. was observed in Kalhaven Orchard V (Table 1). Ordinarily a set of 9 percent is considered low, but with the large

TABLE 1—Thinning effect of maleic hydrazide on Halehaven, Redhaven and Kalhaven peaches when sprayed at different stages of bloom and fruit development (averages from eight trees)

Treatment maleic hydrazide (Con. p. p. m.)	Fruits set per 100 blossom buds	Condition of blossoms at time of spraying
	Halehaven Orchard III,* 1950	
Check	77	*All petals were off 3 days prior to spraying.* Daytime temperatures averaged above 70° F.
50	71	
100	78	
500	17	
	Halehaven Orchard V, 1950	
Check	75	*90 percent of blossoms open.* Temperatures before and after spraying for a three-day period averaged above 70° F. during daylight hours.
50	70	
100	62	
500	27	
	Kalhaven Orchard V, 1950	
Check	52	*70 percent of blossoms open.* Temperatures in the daytime averaged above 70° F. for three days prior to spraying and for two days after spraying.
50	51	
500	9	
	Redhaven Orchard VI, 1950	
Check	59	*Peaches were ¾ inch long and ½ inch in diameter.* Temperatures 83° F., bright.
50	47	
100	48	
500	65	

*Orchard III—Newaygo County.
Orchard V—Oakland County.
Orchard VI—Berrien County.

quantity of bloom present in this Kalhaven block of trees, the reduced set was satisfactory (Table1). The 17-percent set in Halehaven Orchard III and the 27-percent set in Halehaven Orchard V show that a high percentage of fruit thinning occurred when the blossoms were sprayed with maleic hydrazide at 500 p. p. m., as compared with sets of 77 and a 75 percent on untreated trees (Table 1). However, in both instances,

TABLE 2—Thinning effect of maleic hydrazide on Halehaven and Redhaven peaches when sprayed at different stages of bloom (averages from eight trees)

Treatment maleic hydrazide (Con. p. p. m.)	Fruits set per 100 blossom buds	Condition of blossoms at time of spraying
	Halehaven Orchard V,* 1951	
Check	35	*90 percent of blossoms open.*
100	25	
200	26	
300	21	
400	19	
500	16	
	Redhaven Orchard V,* 1951	
Check	33	*All blossoms open.* Some blossoms in the "calyx" stage.
100	22	
200	17	
300	16	
400	16	
500	13	
	Halehaven Orchard VII,† 1951	
Check	45	*90 percent of blossoms open.*
100	46	
200	46	
300	45	
400	39	
500	32	
	Redhaven Orchard VII†, 1951	
Check	34	*All blossoms open.* Some petals already off.
100	33	
200	26	
300	29	
400	23	
500	19	

*Orchard V—Oakland County.
†Orchard VII—Genesee County.

too many peaches still remained for the trees to mature high quality 2½-inch fruits.

In 1951, a reduction in set was secured when maleic hydrazide was sprayed on the peach blossoms at a concentration of 500 p. p. m. (Table 3). Nevertheless, the reduced set which occurred in both Halehaven orchards and in both Redhaven orchards was still too great

for the trees to mature 2½-inch fruits without additional hand thinning.

Maleic hydrazide when sprayed on the peach blossoms at 500 p. p. m. in 1952 reduced the set of Halehaven for the third time in as many years (Table 3). The concentration of 750 p. p. m. reduced the set to 10.5 fruits for each 100 blossoms, which is considered generally satisfactory. Fruit set on the Elberta variety was reduced from 36 to

TABLE 3—Thinning effect of maleic hydrazide on Halehaven and Elberta peaches when sprayed at different stages of bloom (averages from eight trees)

Treatment maleic hydrazide (Con. p. p. m.)	Fruits set per 100 blossom buds	Condition of blossoms at time of spraying
	Halehaven Orchard VII,* 1952	
Check	25.7	*Just past full bloom.* Temperature three days before spraying and during spraying, 70° F. After spraying, temperatures remained 70° F. for several days.
500	19.7	
750	10.5	
1000	7.4	
	Elberta Orchard VII, 1952	
Check	36.5	*90 percent of blossoms open.* Temperatures same as for Halehaven, same orchard, sprayed same day.
500	15.0	
750	7.0	
1000	7.3	

*Orchard VII—Genesee County.

15 percent when sprayed at 500 p. p. m. during bloom, and this percentage of set in the average orchard is satisfactory. A concentration of 750 p. p. m. reduced the set to 7 percent which was too great a reduction.

When peaches were sprayed with maleic hydrazide at about the time of June drop, there was little, if any, effect upon thinning. This is in contrast to the rather remarkable amount of thinning which occurred when the chemical was sprayed at the time of full bloom, as shown in Redhaven Orchard VI (Table 1).

DISCUSSION

It should be noted that the percentage set of fruit for the checks in various orchards in Michigan during 1950 and 1951 was much higher

than normal for Michigan conditions. Ideal blossom periods of high temperatures and high sunlight intensity occurred in those years. In 1952 the Halehaven set was more nearly normal, being 25 percent, and the Elberta set of 36 percent was a little above normal.

It is evident that maleic hydrazide will reduce the set of peaches at various stages of bloom with no visual damage either at time of spraying or at harvest time or to the next year's crop. That maleic hydrazide is not injurious to the foliage of the tree has been noted by Kennard, Tukey, and White.[1]

That maleic hydrazide will prevent fruit set was observed by Chadwick, Miller and Erskine[2] using ornamental trees, *Ginkgo biloba,* sprayed while in full bloom. Those trees showed no injury either at time of spraying or later.

Apparently maleic hydrazide is somewhat selective in its removal of fruits at certain concentrations. Limbs or parts of limbs showing physiological weakness were thinned 100 percent. In addition, double-blossom buds that commonly set on untreated limbs failed to set in every case on limbs sprayed at 500 p. p. m. or above. It is evident that Elberta thins more easily than Halehaven (Table 3, 1952).

SUMMARY

1. Data compiled during three seasons indicate that the fruit set of several varieties of peaches can be reduced by maleic hydrazide at concentrations of 500 p.p.m. or above.
2. The data support the possibility of a longer effective period of thinning peaches by the use of maleic hydrazide than by dinitro compounds.
3. The possibility of a varietal difference in the thinning efficiency of maleic hydrazide is indicated.
4. The gradation in set at the higher concentrations may be interpreted as a degree of selective thinning as to vigor, stage of blossom, or phase of fruit development.

[1]Kennard, William C., Tukey, Loren D., and White, David G. Further Studies with Maleic Hydrazide to Delay Blossoming of Fruits. Proc. Amer. Soc. Hort. Sci. 58: 26-32. 1951.

[2]Chadwick, L. C., Miller, R. R., and Erskine, Donald. The Prevention of Fruit Formation on Some Ornamental Trees. Proc. Amer. Soc. Hort. Sci. 58: 308-312. 1951.

ESTRUS IN SHEEP AND BREEDING EARLY OR OUT OF THE NORMAL SEASON[1]

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SHEEP ARE THE ONLY seasonal breeders among farm animals. However, some breeds of sheep are more truly seasonal than others. Under most conditions and with most breeds, the breeding season is during late summer, fall and early winter. Certain breeds, such as the Dorset Horn and Merino, will breed in other seasons and are frequently used to produce other than spring lambs. In certain areas in the United States some flocks are bred during July for December lambing. Such lambs are fed out, using grains, by-products like beet pulp, and hay. These lambs never go to pasture and are marketed as "hot-house" lambs, usually for the Easter trade or at 80- to 90-pound weights in June. With sheep numbers on the increase there is a need for making the breeding and production program more flexible to fit the needs of producers and consumers. More information is, therefore, desirable on the breeding habits of ewes of different breeds and ages.

To obtain some information regarding the occurrence of the heat or estrus period of ewes at other than the fall breeding season, a flock of 47 yearling ewes was given daily observations from January 15 to August 31, 1951. These ewes were born in the College flock between November 1, 1949 and May 1, 1950, so at the start of the experiment their ages ranged from 8½ months to 14½ months. The flock consisted of 3 Dorset Horn ewes, 7 Hampshire, 5 Oxford, 8 Rambouillet-Dorset Horn crosses, 16 Shropshire, 7 Southdown and 1 Suffolk. One Hampshire and two Suffolk yearling ewes were added to the flock on May 12 and July 21, respectively.

Although these numbers are small and may not be typical of larger flocks, it was believed worthwhile to report the findings since they are representative for this group of yearlings.

[1]The major part of this article is taken from a Master's Thesis in Animal Husbandry by the senior author.

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The flock was housed in a barn up to May 11 and fed the following ration: Soybean oil meal, 1/10 pound; oats and corn (equal parts), 1 pound; mixed alfalfa hay, 2 pounds; and corn silage, 4 pounds per head daily. From May 11 to August 31, the ewes grazed on mixed pasture of alfalfa, clover and brome grass.

Checking for estrus was done with aproned rams once a day up to August 12, and thereafter twice a day up to August 31. The rams were kept separate from the ewe flock except at checking time.

DURATION OF ESTRUS AND LENGTH OF ESTRUS CYCLE.

In this study duration of estrus was considered that period of time when the ewe would mate with the ram to when she refused the ram. During the entire period of observation, 38 estrual periods were observed in the flock. No periods of less than 12 or longer than 72 hours were observed. In nine periods, the length was more than 12 and less than 24 hours, while in three, the duration was more than 48 but less than 72 hours. In a total of 26 periods or about two-thirds of those observed, the duration was more than 24 but less than 48 hours. It was noted that the Shropshire ewes had more of the shortest periods and the Hampshire more of the longest periods than ewes of any other breed. Changes in length of estrus for the same ewe or for succeeding periods were observed in ewes of almost all breeds.

The minimum and maximum estrual cycle lengths observed were 15 and 18 days, respectively, with an average of 17 days. Ewes of different breeds had long periods of sexual inactivity during the experiment. The maximum and minimum length of such periods was 122 and 36 days, respectively.

NUMBERS OF EWES IN HEAT

From January through March, none of the Dorset Horn ewes was observed in heat, but in April two of the three ewes showed estrus. They were sexually inactive in May and June. In July, two of the three, and in August all three were observed in heat.

The Hampshire ewes were sexually quiet from January through March, but one out of six was observed in heat during April. During May and June none was in heat, but one came in heat in July, and five during August.

The Oxford ewes remained sexually inactive during January, February, May, June, and July. However, during March, April, and August, two, one, and one of them, respectively, were found in heat.

The Rambouillet-Dorset Horn crossbred ewes remained quiet during January, March and April. During February, May, June, July, and August, one, one, two, five, and four, respectively, were found in heat.

Likewise, none among the Shropshire ewes was observed in heat from January through March, and May through July. In April and August one and four came in heat.

The Southdown and Suffolk ewes exhibited the longest period of sexual inactivity, which extended from January to the end of July. In August, two of the six Southdown ewes observed were in heat while one of three Suffolk ewes was in heat.

ONSET OF THE BREEDING SEASON

From the foregoing information, it may be seen that varying numbers of ewes came in heat from February to April except the Southdown and Suffolk groups. It was, however, noted that none of the ewes that came in heat during the Spring repeated for the second time after a normal interval.

On the other hand, the earliest heat that was followed by the normally recurring ones, was observed in the last week of June. From then on the ewes of all breeds except Oxfords started coming in heat, earlier in some, and later in the others. The breeding season commenced in the last week of June and first week of July for the Dorset Horn and Rambouillet-Dorset Horn crosses, the end of July for Hampshire, the third week of August for Shropshire, and in the last week of August for the Southdown and Suffolk ewes.

ESTRUS IN EWE LAMBS

The lambing record of 22 ewe lambs of the College Hampshire, Oxford, and Shropshire flocks were available. These ewe lambs were bred by chance while on pasture. The breeding dates were calculated from their lambing dates, with a gestation period of 147 days which showed that the average age at which these ewe lambs settled was 256 days. The range in age was from 231 to 297 days.

OCCURRENCE OF HEAT AFTER LAMBING

Little information is available on the exact time of heat occurrence in ewes after lambing or after the lambs are weaned. This is especially

important when more than one lamb crop is produced, or if early fall lambs are weaned when one month of age or older. In the latter case it is a common plan to breed the ewe at the desirable time to lamb in the Spring.

Records on the College experimental flock show nine Dorset ewes that came in heat from 15 to 34 days following weaning of their lambs. The lambs were weaned on November 26, 1951. The breeding date was arrived at by calculating 147 days previous to the date of lambing the following spring. Thus, it was found that three ewes were bred 15 days after weaning the lambs, one 22 days, one 24 days, one 30 days, one 33 days, and one 34 days. One Hampshire ewe was bred 33 days after weaning her lamb. Another Dorset ewe which dropped twin lambs October 9, and the lambs were weaned October 12, was bred November 3, or 22 days after the lambs were weaned.

Another record on 14 Dorset ewes enrolled in the 1951 Wolverine Lamb Production Project shows that Dorset ewes may breed while nursing their lambs. These 14 ewes dropped 28 lambs between March 1 and 31. Nine of these 14 ewes also dropped 17 more lambs between October 15 and 24. Thus, these 9 ewes were bred from about May 21 to 30, based on a 147-day gestation period. Based on those dates some of these ewes may have been bred only 50 days after lambing, or they may have been bred as long as 90 days after lambing but in each case while the ewes were still nursing lambs.

CONCLUSIONS

1. The duration of estrus in 38 periods varied from more than 12 to more than 48 hours, but the majority of the periods were more than 24 and less than 48 hours in length irrespective of the breeds. The majority of the periods of 12 to 24 hours' duration were observed in the Shropshire ewes, while periods longer than 48 hours were more frequent in the Hampshire ewes.
2. Length of estrus cycles varied from 15 to 18 days, with an average of 16.71 days.
3. The Suffolk and Southdowns, in this instance, were the only breeds of those studied which did not have at least one ewe with a single heat period during February, March, April, May, June or July. (Table 1).

TABLE 1—Number of ewes in heat

Breed	Jan.		Feb.		March		April		May		June		July		August	
	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat	No. observed	No. in heat
Dorset Horn	3	..	3	..	3	..	3	2	3	..	3	..	3	2	3	3
Hampshire	7	..	7	..	6	..	6	1	5	..	5	..	5	1	6	5
Oxford	5	..	5	..	5	2	5	1	5	..	4	..	4	..	4	1
Rambouillet:– Dorset Horn	8	..	8	1	8	..	8	..	8	1	7	2	6	5	6	4
Shropshire	16	..	16	..	16	..	16	1	16	..	16	..	14	..	11	4
Southdown	7	..	7	..	7	..	6	..	6	..	6	..	6	..	6	2
Suffolk	1	..	1	..	1	..	1	..	1	..	1	..	1	..	3	1

4. The data indicate that ewes of all the breeds studied underwent one or more periods of sexual inactivity in late winter, spring, or early summer. The breeding season with regular successive heat cycles began in the last week of June, and by the end of August a representative number of all breeds except Oxford had been in heat. Dorset Horn and Rambouillet-Dorset Horn crossbred ewes started coming in heat earliest and were followed by the Hampshire ewes which started 3 weeks later. For the Shropshire, Southdown, and Suffolk ewes, the breeding season was delayed 6 to 7 weeks longer than was true for the Dorset Horn and Rambouillet-Dorset Horn crossbred ewes.
5. The breeding season for this group of yearlings began when the average minimum temperature was higher than any other month from March to August.
6. The onset of estrus in 22 ewe lambs, as calculated from the lambing dates, occurred at an average age of 256 days, with a range from 231 to 297 days.
7. One Hampshire and nine Dorset Horn ewes observed were bred from 15 to 34 days after weaning early fall lambs in October and November.
8. Farm data from a very closely supervised flock of Dorset ewes shows that in a flock of 14 ewes which lambed in March, 9 of them were rebred 50 to 90 days after lambing, while the lambs were still nursing. This seems to be a common practice with ewes of this breed.

CUTTING CHARACTERISTICS OF DIFFERENT POWER SAW CHAIN DESIGNS

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THE USE of power equipment for the felling and bucking of trees and logs represents one of the latest and most successful attempts toward mechanization of the logging industry. The last decade has seen power saws ridiculed, resented, and finally accepted quite generally by large and small operators.

The final acceptance of the power saw as the working companion of the old-time logger came about slowly, and in some areas the crosscut saw is still very much in evidence. The younger generation of loggers, however, quickly accepted the power saw as an interesting and profit-making tool that would lessen their work and increase their production.

When power saws first became available for general use, they were not the finished production tool that we know today. They were high in cost, cumbersome and heavy, difficult to start and expensive to maintain. In addition, they produced annoying fumes and vibrations, and it was frequently difficult—if not almost impossible—to secure repair parts and services. Through research and engineering, the weight-horsepower ratio has been sharply reduced by the use of lighter metals, principally aluminum and magnesium. Mass production and competition have brought the price down to a reasonable figure, and greatly expanded service facilities have solved most maintenance problems. The increased working hazard attendant upon exhaust noises and increased cutting speed has been greatly minimized by proper selection and training of working crews.

When attempting a comparison of two or more power saws of different manufacture, a great number of variables present themselves. To test all of these variables at the same time would result in the collection of so much data that it would be extremely difficult, if not impossible, to properly evaluate the information. This experiment is con-

[1]Acknowledgments are due to Dr. W. D. Baten, Experiment Station Statistician, for his assistance with the statistical phase of this problem and to T. C. Weill for assistance in collecting the data.

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cerned with the determination of the effect of differences in chain design upon power consumption and cutting time. With the idea in mind of limiting the number of variables, all test cutting was done with a standard power source which drove the test chains at a pre-determined and constant speed in feet per minute. Four different types or designs of power saw chains were tested.

Many variables are present and were given consideration when the experiment was designed. Temperature of timbers being cut was maintained at average room temperature during the progress of the test. Proper chain tension was secured by checking tension according to the manufacturer's recommendation of allowing one-quarter inch of slack under the chain when lifted by the thumb and forefinger, at the mid-point of the blade. All test chains were provided the same type and quantity of lubricant prior to the start of each test cut. By using test timbers cut from five different and representative species of trees, differences among wood species were taken into account. Differences in wood densities within a species were minimized by making successive cuts at one-inch intervals along the test timbers, and only clear wood was cut.

In all testing done to date, only freshly cut green timbers were used. Moisture tests made on tested material indicated that all test timbers were well above the fiber-saturation point, i.e., above 30 percent of moisture. The moisture content of some timbers ranged from 42 to 74 percent, based on oven-dry weight. The idea that wet wood cuts more easily than dry wood is accepted as a fact, but the idea presents itself that the amount of moisture, either above or below fiber saturation point, may have a decided effect on the power consumed in cutting. This possibility can be checked in future testing.

The tests which have been completed were made using sample chains furnished by cooperating chain manufacturers.[2] These test chains were used just as they were received from the manufacturer and, for this part of the experiment, were not sharpened or altered in any way other than to cut them to proper length to fit on the testing blades.

Further tests will be made which will duplicate those described in this paper, except that all test chains will be sharpened according to the manufacturer's specifications, just prior to starting the test.

Finally, each properly sharpened chain will be used to cut to a prescribed depth in a laminated timber containing an abrasive. This abrasive-containing timber will be laminated from one-inch boards held together with a glue contain-

[2]McCulloch Motors Co., Los Angeles, Calif., and Lombard Governor Corp., Ashland, Mass.

ing carborundum dust. Thus by controlled dulling of each chain, its comparative service life under comparable cutting conditions will be evaluated.

TESTING EQUIPMENT

Figure 1 shows the set-up of the testing equipment. It includes: 1) three-H. P. electric motor with attached speed ranger, 2) gravity rolls for support and movement of the timber or cant to be cut, 3)

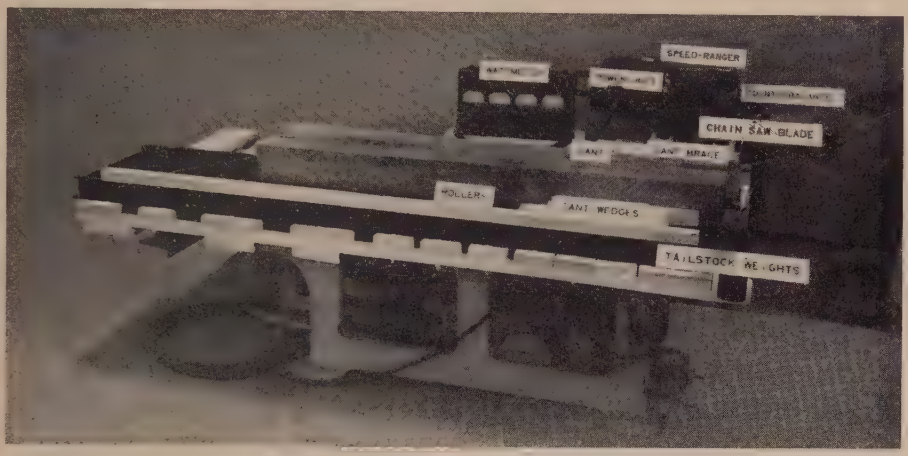

Fig. 1. Testing equipment. Complete setup of equipment, with exception of the saw chain, which has been removed from the chain saw blade.

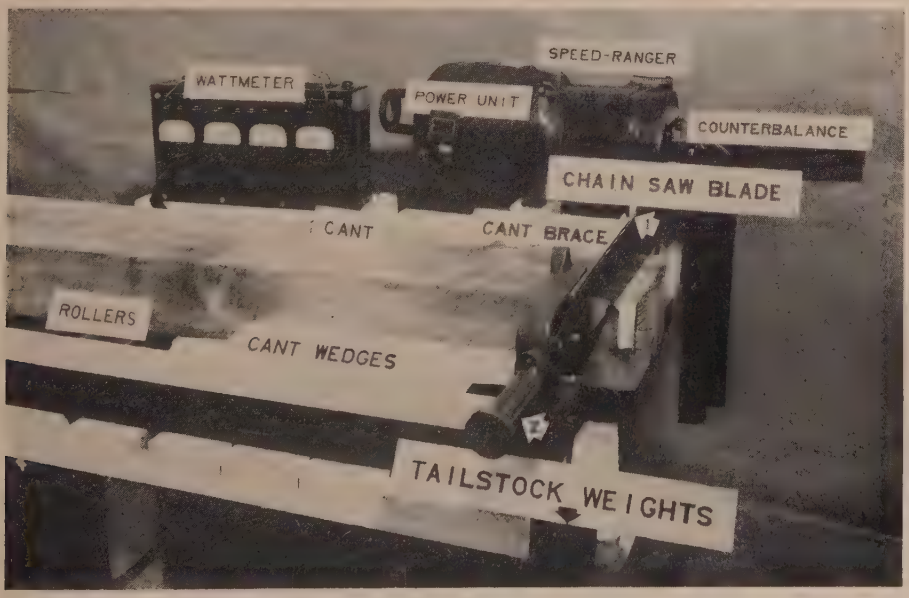

Fig. 2. Testing equipment detail. Close-up of the essential parts of testing equipment, minus saw chain. Recess for chain seat shown on chain saw blade.

tapered wedges for anchoring the timber in position during cutting, 4) power saw blade (without chain), 5) counter-balance weight, 6) tailstock weights, 7) wattmeter for recording power consumption.

TESTING MATERIALS

As previously stated, four different chain designs were used in these tests. Three samples of each design were supplied by the manufacturer, making a total of 12 individual chains tested. The chain designs used in these experiments are identified as follows (Figs. 3 and 4):

Chain design "A".....Warren High Speed,
Chain design "B".....Rip-crosscut, type "M,"
Chain design "C".....Saber-tooth, type "J,"
Chain design "D". Rip-crosscut, heavy duty, type "F."

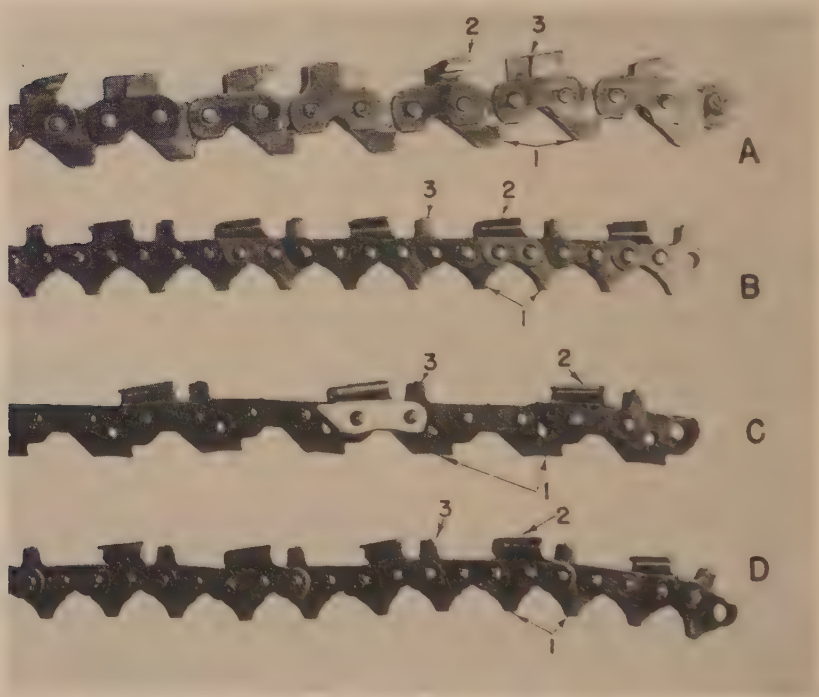

Fig. 3. Chain designs. Examples of assembled chains of the four different designs tested. (Letters refer to chair designs mentioned in the text.)

1. Chain seat, to fit in slot in chain saw blade.
2. Cutting teeth; right and left cutters.
3. Depth gauges, to regulate depth of tooth bite.

Five different species of wood were used for testing the chains. These species were hard maple (*Acer saccharum*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), American elm (*Ulmus americana*), and basswood (*Tilia americana*). The timbers cut from these

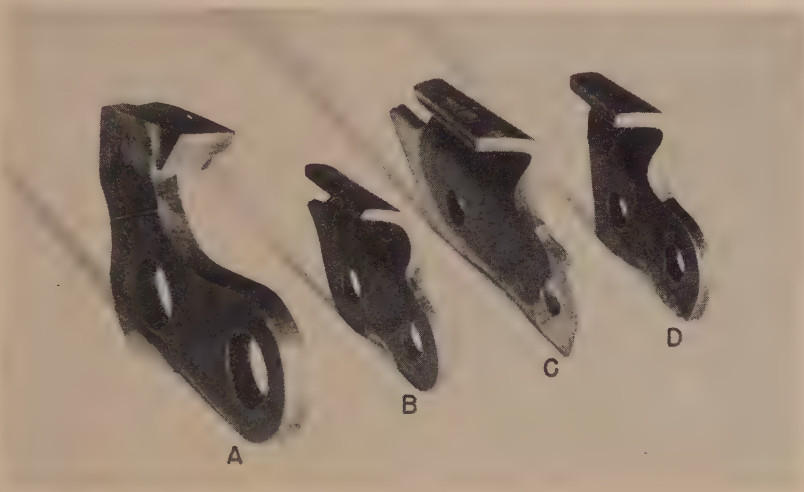

Fig. 4. Chain designs, cutting teeth detail.

A. Warren High Speed.
B. Rip-crosscut, Type "M".
C. Saber-tooth, Type "J".
D. Rip-crosscut, Heavy Duty Type "F".

species were boxed-heart, 6″ x 12″ x 10′ pieces; they were used in the rough. All timbers were fresh sawn, with moisture content ranging from 48.6 to 78 percent.

PROCEDURE

Because of the differences in chain design, two different saw blades and drive sprockets had to be used in the test. The heavier of these two blades was counter-balanced at the power end so that both blades would have equal bearing pressure on the timber to be sawed.

By checking a gasoline engine driven power saw unit at full speed, an average drive sprocket speed of 1200 R. P. M. was determined, which gave a chain speed of 1600 F. P. M. When the drive sprocket and blade were changed to accommodate another chain design, the

necessary adjustments in R. P. M. were made on the speed-ranger to readjust the chain to 1600 F. P. M.

The timber to be cut was placed on the gravity rolls and positioned under the chain and blade assembly so that a short cross-section approximately 1½ inch in length could be cut off. After the chain had been lubricated, it was checked for proper tension by lifting the chain at the midpoint of the blade, with thumb and forefinger. With proper tension it was possible to lift the chain approximately ¼ inch from the blade before it snapped out of the fingers.

With the power turned on, the wattmeter reading was observed and recorded with the chain in motion, but not engaged in cutting. The blade was then lowered and the moving chain allowed to contact the timber. Since the first point of contact was a corner of the timber, cutting time was not recorded until the chain had cut through to the opposite top corner, i.e., recording of cutting time was started when the cut was a full 12 inches wide. Time of cut was recorded by a minute-decimal stop watch, and power consumption was read from the wattmeter when the timber was cut approximately half through. Maximum power in the cut, minus the power consumption of the chain before engagement, gave net power consumption during the cutting. If any chain did not cut half way through the timber during a full minute of elapsed cutting time, the chain was disengaged and the depth of cut recorded. Otherwise, the cut was continued until the chain had dropped through to the stop below, and the time elapsed in cutting off the section was recorded.

Two test cuts were made with each chain on each of the five species of wood used at tailstock pressures of 0, 5, and 10 pounds. These weights were attached to each blade exactly 45 inches from the center of the drive sprocket.

Each chain made 30 cuts, and since there were three chains of the same design, 90 cuts were made for each design, with a total of 360 cuts for the four chain designs used in the experiment.

The parts of a power saw used in this experiment are shown in Fig. 1 and in greater detail in Fig. 2. In both figures, the chain has been removed from the chain saw blade. The seat, or tang of the chain fits into the slot or recess in the chain saw blade and slides in this groove as the hinged chain moves around the outer edge of the chain saw blade.

Analysis of variance was run on the data to evaluate the results.

INDIVIDUAL CHARACTERISTICS OF CHAINS

CHAIN DESIGN "A"—WARREN HIGH SPEED

Chain "A" has a file-hard, chisel-type cutting tooth, and cuts a kerf approximately 3/8" wide. The hardened cutting teeth are attached to the chain proper by means of a special metal-bonding process. The cutting teeth are machine sharpened at the factory with a carborundum wheel. Comparison of the four cutting teeth from the four chain designs in Fig. 4 illustrates their respective shapes, and also gives a comparison of their different degrees of sharpness. These teeth seem to dig out the wood fibers by planing them off at the bottom of the kerf, and then breaking or tearing them loose at either side. The cut surface was found to be quite smooth, with scattered torn fibers.

CHAIN DESIGN "B"—RIP-CROSSCUT, TYPE "M"

Chain "B" has a curved type of cutting tooth, which seems to produce more of a slicing action on the wood fibers being cut; the cut surface was somewhat ridged, resembling a washboard in appearance. There was little or no evidence of any torn fibers. With tailstock pressure of 0 pound, the chain had a tendency to jump in the cut, but became somewhat steadier as the pressure was increased to 5 and 10 pounds. The kerf, because of the jumpiness of the chain, was approximately 5/8" inch wide.

Only one of the three samples of chain "B" gave any cutting data. The other two samples would not perform within the time limits of this experiment. This would seem to indicate that these chains are not ready for production when they leave the factory. Test results for "B" chains were eliminated from all computations. These same chains will be sharpened according to the manufacturer's specifications, and used in later tests.

CHAIN DESIGN "C" SABER TOOTH, TYPE "J"

Chain "C" has a chrome-plated cutting tooth. Tooth shape, as illustrated in Fig. 4, is curved, with a semi-flattened top. Figure 4 also illustrates that the cutting edge is roughened, with occasional wire-edged areas. With a tailstock pressure of 0 pound, the chain was very jumpy in the cut, and as a result produced a kerf that was as wide as 7/8 inch. The wider spacing of the cutting teeth probably accounts for this, at least in part (Fig. 3). As tailstock pressure was increased, the chain became steadier in the cut. The cut surfaces resulting from the use of chain "C" were very rough in all of the species tested except

basswood. With basswood, however, the cut surface was as smooth as with any of the other chain designs tested, and the kerf narrowed down to slightly over ½ inch.

CHAIN DESIGN "D"—RIP-CROSSCUT, HEAVY DUTY TYPE "F"

In this chain design tooth shape is curved, with a semi-flattened top, as shown in Fig. 4. The roughened cutting edge is also clearly shown in Fig. 4. Chain "D" was somewhat jumpy in the cut under all tailstock pressures, but not so much as chain "C". Power consumption was the lowest and cutting time longest on this design of all chain designs tested.

DISCUSSION

This report deals with the first phase of the experiment set up to evaluate cutting characteristics of different power saw chain designs.

TABLE 1—Average net power consumption in kilowatts by chain design and tailstock pressure

Chain design	Species	Tailstock pressures, in pounds			Average of all pressures, in pounds
		0	5	10	
A.....	White Oak.....	0.487	0.907	1.340	0.911
	American Elm.....	.520	.933	1.333	.927
	Hickory.....	.527	.940	1.287	.918
	Sugar Maple.....	.670	1.100	1.487	1.086
	Basswood.....	.480	.847	1.240	.856
	Average, all species.....	0.537	0.945	1.337	0.940
			Average = 0.940		
C.....	White Oak.....	0.853	1.467	2.153	1.491
	American Elm.....	.860	1.500	2.153	1.504
	Hickory.....	.960	1.600	2.147	1.569
	Sugar Maple.....	1.033	1.547	2.340	1.640
	Basswood.....	.847	1.527	2.047	1.474
	Average, all species.....	0.911	1.528	2.168	1.536
			Average = 1.536		
D.....	White Oak.....	0.395	0.593	0.967	0.652
	American Elm.....	.580	.960	1.273	.938
	Hickory.....	.513	.580	.827	.640
	Sugar Maple.....	.540	.593	1.160	.764
	Basswood.....	.720	.907	1.260	.962
	Average, all species.....	0.550	0.727	1.097	0.791
			Average = 0.791		

The test chains were used exactly as they were received from the manufacturer, and after careful inspection of the chains prior to testing, many of the results of the first tests could be anticipated.

By virtue of its design and fabrication, chain design "A" of necessity had to be very carefully machine sharpened before being offered for use on a saw. Chain designs "B", "C" and "D", by comparison, were not so well sharpened when received for testing (Fig. 4). These observations were later borne out by the results of the cutting tests. The data collected from the tests with chain design "B" were so fragmentary that this design had to be eliminated from the analysis of results and also from all computations for Tables.

Inspection of Table 1 indicates that an increase in tailstck pressure resulted in an increase in power consumption. This held true for all three chain designs.

TABLE 2—Average cutting time in minutes, by chain design, species and tailstock pressure

Chain design	Species	Tailstock pressures, in pounds			Average time all pressures, in minutes
		0	5	10	
		Cutting time in minutes			
A.....	White Oak.....	0.687	0.374	0.266	0.442
	American Elm.....	.672	.313	.238	.408
	Hickory.....	.594	.377	.271	.414
	Sugar Maple.....	.565	.328	.254	.382
	Basswood.....	.603	.289	.329	.407
	Average, all species.....	0.624	0.336	0.272	0.411
		Average = 0.411			
C.....	White Oak.....	1.199	0.665	0.464	0.776
	American Elm.....	.891	.487	.330	.569
	Hickory.....	1.084	.641	.430	.718
	Sugar Maple.....	1.378	.749	.510	.879
	Basswood.....	.438	.250	.163	.284
	Average, all species.....	0.998	0.558	0.379	0.645
		Average = 0.645			
D.....	White Oak.....	1.454	1.263	0.993	1.237
	American Elm.....	1.010	.826	.520	.785
	Hickory.....	1.374	1.285	1.170	1.276
	Sugar Maple.....	1.374	1.243	.864	1.160
	Basswood.....	.555	.539	.347	.480
	Average, all species.....	1.153	1.031	0.779	0.988
		Average = 0.988			

If the values for power consumption at all tailstock pressures are averaged for each chain design, chain "D" indicates the lowest power consumption with 0.791 kilowatt, chain "A" is next with 0.940 kilowatt, and chain "C" the highest of all three with 1.536 kilowatts. However, when these results are considered in conjunction with comparable averages for cutting time from Table 2, it becomes apparent that power consumption alone is a poor indication of cutting ability. When one considers cutting time separately, chain "A" demonstrates the lowest average time, with 0.411 minute for all species and all tailstock pressures. Chain "C" is next with 0.645 minute and chain "D" is highest with 0.988 minute. The significance of these results is confirmed by the analysis of variance.

A better comparison between chain designs is shown by average energy consumption expressed in kilowatt hours, which is the product of average power consumption expressed in kilowatts and average time in minutes, multiplied by 60. These comparative values are presented

TABLE 3—Energy consumption in kilowatt-hours

Chain design	Tailstock pressure, in pounds	Power consumption in kilowatts	Cutting time in minutes	Energy consumed in kilowatt-hours	
				Average by pressure	Average by design
A	0	0.537	0.624	20.106	20.326
	5	.945	.336	19.050	
	10	1.337	.272	21.822	
		Av. 0.940	Av. 0.411		
C	0	0.911	0.998	54.552	51.670
	5	1.528	.558	51.156	
	10	2.168	.379	49.302	
		Av. 1.536	Av. 0.645		
D	0	0.550	1.153	38.052	44.766
	5	.727	1.031	44.970	
	10	1.097	.779	51.276	
		Av. 0.791	Av. 0.988		

in Table 3. Consumed energy gives a more realistic picture of the cutting characteristics of the test chains, because it reflects the influence of both power and time. From these values, the conclusion may be reached that under experimental procedures used, chain "A" demonstrated marked superiority over both chains "C" and "D".

CORRELATION OF WALNUT FURNITURE CUTTING REQUIREMENTS WITH GRADE YIELD

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LUMBER IS THE BASIC raw material of the furniture industry. According to the Forest Resource Report for 1948, annual consumption in furniture manufacture exceeds two billion board feet. Despite this tremendous volume and the amount of money it represents cost-wise to furniture manufacturers, this lumber is not always used wisely. Few manufacturers know the proper grade of lumber to purchase to produce furniture parts most economically.

Present-day incentive systems in use in factories generally hinder conservation of lumber. If the system is such that a bonus is paid according to the time saved over a standard time for completion of a number of pieces, then the cutting crew is continually applying pressure on the purchasing agent to buy higher grade lumber, so fewer defects will have to be removed.

Requirements for clear lumber in the plant in which this study was made are probably somewhat above average because of the large size furniture made and also because of the wide widths necessary where glue joints are not acceptable. However, the basic problem remains the same. The question to be answered is what grade of lumber should be purchased to meet the cutting requirements most economically for any given lot of furniture.

In determining the economy of one grade of lumber over another for producing wood parts, there are several cost factors to consider. These are: 1) the yield of usable cuttings obtained from a given amount of rough lumber, 2) handling costs, 3) freight charges, 4) kiln drying, and 5) costs of cutting. It is clearly evident that lowering the lumber grade for a specific material bill will increase waste and require that more rough lumber be handled to produce a specified amount of cut stock. Therefore, once it has been found that a lower

ARTICLE 35-30

grade lumber will meet requirements, it must be determined whether the price differential between the lumber grades will offset the increased manufacturing costs. Finally, when it is definitely shown that a lower grade lumber will satisfy cutting requirements at lower cost, the manufacturing time and available facilities involved in producing parts from lower grade lumber must be considered.

Even though management of a furniture company may feel that lumber of too high a quality is being purchased for the product, there are usually no data available that would allow management to ascertain definitely what grade of lumber is the most economical. It was the purpose of this study to develop a method of approach that would permit any lumber user to determine the relative economy of obtaining cuttings of desired sizes from the different grades of lumber.

Two-inch walnut was chosen as the first species to be studied because it is cut in considerable volume and has a relatively high waste factor. The study was conducted at the Baker Furniture Company plant, Holland, Michigan.

PROCEDURE[1]

Requirements in different cutting sizes and possible yields of these sizes from each grade are closely related. These two factors, when balanced by variations in cost of manufacture, form a real basis for a choice between lumber grades. Relationships between them may be determined by the procedure described in the paragraphs that follow.

DETERMINATION OF CUT STOCK REQUIREMENTS

A materials bill must be made up, showing all the information given in the sample form, Table 1. In the plant in which this study was undertaken, furniture is built to order and no definite material list could be made far in advance of production. It is estimated, however, that there would be no great deviation from one year to the next, and the number of cuttings required in 1951 is therefore taken as a balanced list of cutting sizes.

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[1]The definition of these four terms as used in this paper is necessary for understanding of the results of the study:

Residue Percentage—The percentage of the clear, defect-free lumber that must be wasted to produce required cuttings. Residue and the defective parts of the lumber combined comprise the total waste.

Use Percentage—The percentage of the rough lumber footage that can be cut to usable cut-stock sizes.

Net Footage—The actual board footage of cut stock.

Surface Footage—The surface area of the board in square feet.

TABLE 1—8/4 Walnut cutting requirements for 1951

Style No.	Item	Part	No. of parts required	Cutting dimension, inches		Pieces to make part	Glue joints allowed	Pieces per cutting	Total cuttings required per item	Number of items					No. of cuttings required Col. 10 x Col. 15
										Run				Total	
				Length	Width					1	2	3	4		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
2522	Lamp table	Legs	4	24	1 9/16	1	no	1	4	100	75			175	700
		Front top Fret rail	1	19	¾	1	no	1	1	100	75			175	175
		Fret Stile	8	15½	¾	1	no	1	8	100	75			175	1400
2513	Bench	Base Frame Rails	4	17¼	2¾	1	no	1	4	30	75			105	420
		Legs	2	17½	3¼	1	no	2	1	30	75			105	105
2529	Console table	Side top Frame	2	55½	3⅛	2	yes	½	8	75	75	50		200	1600

A table similar to Table 2, summarizing cutting by size classes was next set up. For the materials bill studied, the best size breakdown was as shown in Table 2. A tally was taken from the material bill of the number of cuttings required in each size class, and the totals recorded in the top of each square.

Surface footages for each cutting size were then taken from Table 3 and recorded in the centers of the squares. Next the surface footages were multiplied by the number of cuttings required, to get the total surface footage in each size class. These were recorded at the bottom of each square. Columns and rows were totaled and multiplied by thickness to get the net or board footage. Length class totals were then recorded in Table 6 and percentages of total footage computed for each class. The total net footage derived in this manner may not equal that resulting from a summation of footages calculated directly from Table 1 dimensions because of the lumping into size classes and the assumption that all cuttings in that class contain equal footage. The method is fast, however, and sufficiently accurate for this type of study.

GRADE YIELD

Lumber used in this study was picked at random from a carload of 8/4 walnut. At the Baker Furniture Co. plant all lumber is processed in the following order: cross cut, planed both sides, jointed, ripped. No distinction, therefore, was made between rip-cut and cross-cut type boards. Table 2 indicates a low requirement in cuttings of wide widths, so the sawyer was instructed to cut for long lengths wherever possible. All cuttings were required to be clear.

Yields in the different cutting size classes from each grade may be found by the following procedure:

1. Grade, sort and tally the lumber.

2. Break down the lumber in the rough mill, using the same manufacturing practices as are used on a production run excepting that every attempt should be made to get the longest length and widest width possible without cutting any clear face piece so short that it cannot be used.

3. Tally the resulting cuttings as in Fig. 1. Multiply the number of cuttings by the surface footage for that square, taken from Table 4, and add columns and rows. The resulting surface footage must be multiplied by the thickness to get the board footage yield of clear cuttings from that grade.

TABLE 2—Cuttings, unit surface footage and board footage by size classes

Length class	Width class													Total surface feet	Total board feet
	-1	1-1½	1½-2	2-2½	2½-3	3-3½	3½-4	4-4½	4½-5	5-6	6-7	7-8	8+		
-15	3,730 .07 261.1	400 .12 48.0		325 .21 68.3	280 .26 72.8	700 .30 210.0	330 .35 115.5				145 .61 88.5			864.2	1,728.4
15-18	2,238 .09 201.4	400 .14 56.0	1,265 .20 253.0	1,080 .26 280.8	2,325 .32 744.0	1,930 .37 714.1								2,249.3	4,498.6
18-21	175 .10 17.5		1,030 .24 259.2	514 .30 154.2		285 .44 125.4				648 .74 479.5	25 .88 22.0		45 1.15 51.8	1,109.6	2,219.2
21-24			3,165 .27 854.6			75 .51 38.3							175 1.33 232.8	1,125.7	2,251.4
24-27	3,000 .13 390.0													390.0	780.0
27-30			360 .35 126.0	330 .45 148.5	300 .54 162.0		2,640 .74 1,953.6							2,390.1	4,780.2
30-33			720 .38 273.6	1,210 .49 592.9										866.5	1,733.0
33-36			160 .42 67.2											67.2	134.4

36-39			260 .46 119.6												119.6	239.2
39-42								81 1.20 97.2							97.2	194.4
42-45			40 .53 21.2					36 1.28 46.1							67.3	134.6
45-48																
48-51																
51-54																
54-57				400 .87 348.0		800 1.25 1,000.0									1,348.0	2,696.0
57-60			20 .71 14.0	300 .91 273.0				45 1.73 77.9							364.9	729.8
60-63			320 .75 240.0	64 .96 61.4	150 1.17 175.5										476.9	953.8
63-66																
66-69	160 .35 56.0														56.0	112.0

TABLE 2—Continued

Length class	Width class													Total surface feet	Total board feet
	-1	1-1½	1½-2	2-2½	2½-3	3-3½	3½-4	4-4½	4½-5	5-6	6-7	7-8	8+		
69-72															
72-75				60 1.15 69.0										69.0	138.0
75-78															
78-81	130 .41 53.3			570 1.24 706.8				130 2.35 305.5						1,065.6	2,131.2
Total....	979.3	104.0	2,228.4	2,702.9	1,154.3	2,087.8	2,069.1	526.7	.....	479.5	110.5	.....	284.6	12,727.1	.....
Total Net Footage	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25,454.2

TABLE 3—Surface footage per cutting unit by classes*

Length class	Width classes												
	-1	1-1½	1½-2	2-2½	2½-3	3-3½	3½-4	4-4½	4½-5	5-6	6-7	7-8	8+
15	0.07	0.12	0.16	0.21	0.26	0.30	0.35	0.40	0.45	0.52	0.61	0.70	0.80
18	.09	.14	.20	.26	.32	.37	.43	.49	.54	.63	.74	.86	.97
21	.10	.17	.24	.30	.37	.44	.51	.58	.64	.74	.88	1.02	1.15
24	.12	.19	.27	.35	.43	.51	.59	.66	.74	.86	1.02	1.17	1.33
27	.13	.22	.31	.40	.49	.58	.66	.75	.84	.97	1.15	1.33	1.51
30	.15	.25	.35	.45	.54	.64	.74	.84	.94	1.08	1.29	1.48	1.68
33	.16	.27	.38	.49	.60	.71	.82	.93	1.04	1.20	1.42	1.64	1.86
36	.18	.30	.42	.54	.66	.78	.90	1.02	1.14	1.31	1.56	1.80	2.04
39	.20	.33	.46	.59	.72	.85	.98	1.11	1.24	1.43	1.69	1.95	2.21
42	.21	.35	.49	.63	.77	.91	1.05	1.20	1.34	1.55	1.82	2.11	2.39
45	.23	.38	.53	.68	.83	.98	1.13	1.28	1.43	1.66	1.96	2.27	2.57
48	.24	.40	.57	.73	.89	1.05	1.21	1.37	1.53	1.78	2.10	2.42	2.74
51	.26	.43	.60	.77	.95	1.12	1.29	1.46	1.63	1.89	2.23	2.58	2.92
54	.27	.46	.64	.82	1.00	1.18	1.37	1.55	1.73	2.01	2.37	2.73	3.10
57	.29	.48	.67	.87	1.06	1.25	1.45	1.64	1.83	2.12	2.51	2.89	3.27
60	.30	.51	.71	.91	1.12	1.32	1.52	1.73	1.93	2.23	2.64	3.05	3.45
63	.32	.53	.75	.96	1.17	1.39	1.60	1.82	2.03	2.35	2.78	3.20	3.63
66	.34	.56	.78	1.01	1.23	1.46	1.68	1.90	2.13	2.46	2.91	3.36	3.81
69	.35	.59	.82	1.05	1.29	1.52	1.76	1.99	2.23	2.58	3.05	3.52	3.98
72	.37	.61	.86	1.10	1.35	1.59	1.84	2.08	2.33	2.69	3.18	3.67	4.16
75	.38	.64	.89	1.15	1.40	1.66	1.91	2.17	2.42	2.81	3.32	3.83	4.34
78	.40	.66	.93	1.20	1.46	1.73	1.99	2.26	2.52	2.92	3.45	3.98	4.52
81	.41	.69	.97	1.24	1.52	1.79	2.07	2.35	2.62	3.04	3.59	4.14	4.69
84	.43	.72	1.00	1.29	1.58	1.86	2.15	2.43	2.72	3.15	3.72	4.30	4.87

*Dimensions used in computing footages were the mid-points between upper and lower length and width limits in all size classes.

4. Record Fig. 1 footages by length classes for each grade in Table 6 and compute percentages. Add Table 5 percentages cumulatively and record in Table 6.

Length Class	Width Class													Surface Footage	Board Footage
	1	1-1½	1½-2	2-2½	2½-3	3-3½	3½-4	4-4½	4½-5	5-6	6-7	7-8	8+		
15			• 1		:• 3	•• 2								10.56	21.1
18														3.24	6.5
21														20.62	41.2
24														10.01	20.0
81															
Total	2.87	6.33	13.52	12.91	9.69	17.05	27.47	14.47	47.79	87.32	84.05	48.37	64.61	436.45	872.9

Fig. 1. Sample cutting tally.

At this point the relationship between cutting requirements and grade yields becomes apparent. This relationship becomes more obvious, however, when cumulative percentage yields by length classes are plotted on a graph (Fig. 2).

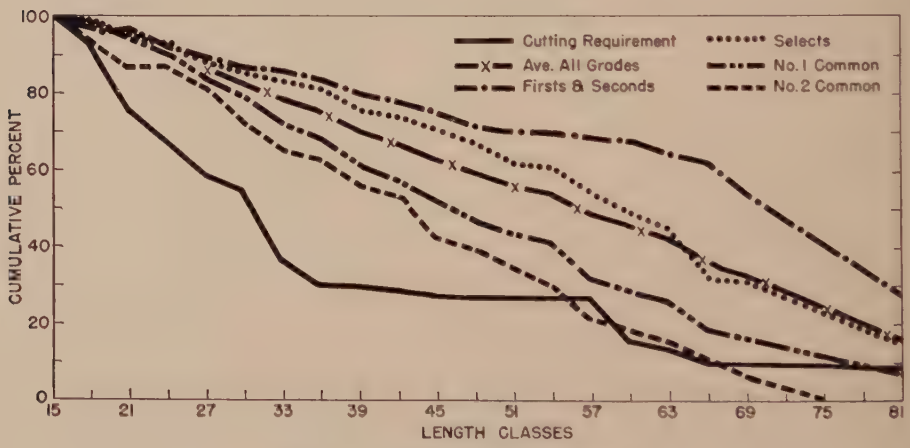

Fig. 2. Cut stock requirements.

By referring to Fig. 1, it will be noted that any grade can be expected to yield the required cutting sizes as long as the line for that grade is above the line showing requirements. Firsts and Seconds,

TABLE 4—Surface footage yields by length and width class

Length classes	Width classes											
	—1	1-1½	1½-2	2-2½	2½-3	3-3½	3½-4	4-4½	4½-5	5-6	6-7	7-8	8+
15	0.09	0.14	0.19	0.23	0.28	0.33	0.37	0.42	0.47	0.54	0.63	0.70	0.82
18	.11	.17	.23	.29	.34	.40	.46	.52	.57	.66	.77	.89	1.00
21	.14	.20	.27	.34	.41	.47	.54	.61	.68	.78	.91	1.05	1.18
24	.16	.23	.31	.39	.47	.55	.63	.70	.78	.90	1.05	1.21	1.27
27	.18	.27	.35	.44	.53	.62	.71	.80	.89	1.02	1.20	1.37	1.55
30	.20	.30	.40	.49	.59	.69	.79	.89	.99	1.14	1.34	1.53	1.73
33	.22	.33	.44	.55	.66	.76	.87	.98	1.09	1.26	1.48	1.70	1.91
36	.24	.36	.48	.60	.72	.84	.96	1.08	1.20	1.38	1.62	1.86	2.10
39	.26	.39	.52	.65	.78	.91	1.04	1.17	1.30	1.50	1.76	2.02	2.28
42	.28	.42	.56	.70	.84	.98	1.13	1.26	1.41	1.62	1.90	2.18	2.46
45	.30	.45	.60	.76	.91	1.06	1.21	1.36	1.51	1.74	2.04	2.34	2.64
48	.32	.48	.65	.81	.97	1.13	1.29	1.45	1.61	1.86	2.18	2.50	2.83
51	.34	.52	.69	.86	1.03	1.20	1.37	1.55	1.72	1.98	2.32	2.67	3.01
54	.36	.55	.73	.91	1.09	1.28	1.46	1.64	1.82	2.10	2.46	2.83	3.19
57	.39	.58	.77	.96	1.16	1.35	1.54	1.72	1.93	2.22	2.60	2.99	3.37
60	.41	.61	.81	1.02	1.22	1.42	1.62	1.83	2.03	2.34	2.74	3.15	3.55
63	.43	.64	.85	1.07	1.28	1.49	1.71	1.92	2.14	2.46	2.88	3.31	3.74
66	.46	.69	.92	1.15	1.37	1.60	1.83	2.06	2.29	2.63	3.09	3.55	4.01
69	.48	.72	.96	1.20	1.44	1.68	1.92	2.15	2.40	2.75	3.23	3.71	4.19
72	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.87	3.37	3.87	4.37
75	.52	.78	1.04	1.31	1.56	1.82	2.09	2.34	2.60	2.99	3.51	4.03	4.56
78	.54	.81	1.08	1.36	1.62	1.89	2.17	2.44	2.71	3.11	3.66	4.20	4.74
81	.56	.84	1.12	1.41	1.69	1.97	2.25	2.53	2.81	3.23	3.80	4.36	4.92
84	.58	.88	1.17	1.46	1.75	2.04	2.33	2.63	2.92	3.35	3.94	4.52	5.10

*Lengths used for determining footages were 13.5 for the 15″ and under class, the midpoint between limits for 18″ through 63″ classes and actual length on classes from 66″ up. Cuttings below 66″ were cut to the longest possible length and hence fell at random within the classes. Cuttings 66″ and above were cut to the exact maximum length in the class. Widths were cut to the nearest ½″. Therefore maximum widths were used in calculations in the 5″ class and below and 5.75, 6.76, 7.75 and 8.75 used in the 6, 7 and 8, and 8+ classes.

TABLE 5—Cutting requirement and grade yield percent by length classes

Length classes	Annual requirement		Firsts and Seconds		Selects		No. 1 Com.		No. 2 Com.		Total	
	B. M.	Percent of total	B. M.	Percent	B. M.	Percent	Ft. B. M.	Percent	Ft. B. M.	Percent	Ft. B. M.	Percent
15	1,728.4	6.8	21.1	2.4	2.1	.6	22.2	2.2	7.6	6.9	53.0	2.2
18	4,498.6	17.8	6.5	.8	12.9	3.6	31.3	3.1	6.1	5.5	56.8	2.4
21	2,219.2	8.7	41.2	4.7	11.6	3.2	44.0	4.3	.5	.5	97.3	4.1
24	2,251.4	8.8	20.0	2.3	16.4	4.5	69.4	6.9	5.6	5.1	111.4	4.7
27	780.0	3.1	25.2	2.9	9.4	2.6	50.3	5.0	11.0	10.0	95.9	4.1
30	4,780.2	18.8	14.7	1.7	7.9	2.2	69.0	6.8	8.0	7.3	99.6	4.2
33	1,733.0	6.8	13.6	1.6	8.8	2.4	42.9	4.2	2.3	2.1	67.6	2.9
36	134.0	.5	37.6	4.3	20.0	5.5	68.7	6.8	8.2	7.4	134.5	5.7
39	239.2	.9	15.2	1.7	7.3	2.0	43.4	4.3	2.8	2.5	68.7	2.9
42	194.4	.8	30.0	3.4	11.8	3.2	50.9	5.0	11.6	10.5	104.3	4.4
45	134.6	.5	25.5	2.9	12.2	3.4	50.3	5.0	4.5	4.1	92.5	3.9
48	.....	....	16.5	1.9	18.7	5.2	36.0	3.6	4.8	4.3	76.0	3.2
51	.....	....	2.1	.2	5.5	1.5	24.7	2.4	5.7	5.2	38.0	1.6
54	.....	....	12.4	1.4	22.2	6.1	91.5	9.0	8.5	7.7	134.6	5.7
57	2,696.0	10.6	3.5	.4	18.9	5.2	35.3	3.5	6.5	5.9	64.2	2.7
60	729.8	2.9	29.4	3.4	14.4	4.0	26.8	2.6	....	....	70.6	3.0
63	953.8	3.7	17.9	2.1	47.0	13.0	72.7	7.2	9.4	8.5	147.0	6.3
66	.....	....	71.7	8.2	2.8	.8	13.5	1.3	....	....	88.0	3.7
69	112.0	.4	230.1	26.4	61.1	16.8	103.1	10.2	7.2	6.5	401.5	17.1
72	.....	....	....	....	....	....	....	....	....	....	....	....
75	138.0	.5	....	....	....	....	....	....	....	....	....	....
78	.....	....	....	....	....	....	....	....	....	....	....	....
81	2,131.2	8.4	238.7	27.3	51.7	14.2	66.5	6.6	....	....	356.9	15.2
Total	25,454.2	100.0	872.9	100.0	362.7	100.0	1,012.5	100.0	110.3	100.0	2,358.4	....

and Selects are well above the line and could, therefore, be used for furniture parts of any length. Yield of cuttings 54″ to 78″ in length from the No. 1 Common exceeds requirements so narrowly that the use of this grade would not be practical. For 54″ cuttings there is still sufficient leeway between need and yield, therefore, the 54″ length

TABLE 6—Cumulative grade yield and requirement percent by length classes

Length classes	Cutting requirement	Firsts and seconds*	Selects	No. 1 Com.	No. 2 Com.	Total
15	100.0	100.0	100.0	100.0	100.0	100.0
18	93.2	97.6	99.4	97.8	93.1	97.8
21	75.4	96.8	95.8	94.7	87.6	95.4
24	66.7	92.1	92.6	90.4	87.1	91.3
27	57.9	89.8	88.1	83.5	82.0	86.6
30	54.8	86.9	85.5	78.5	72.0	82.5
33	36.0	85.2	83.3	71.7	64.7	78.3
36	29.2	83.6	80.9	67.5	62.6	75.4
39	28.7	79.3	75.4	60.7	55.2	69.7
42	27.8	77.6	73.4	56.4	52.7	66.8
45	27.0	74.2	70.2	51.4	42.2	62.4
48	26.5	71.3	66.8	46.4	38.1	58.5
51	26.5	69.4	61.6	42.8	33.8	55.3
54	26.5	69.2	60.1	40.4	28.6	53.7
57	26.5	67.8	54.0	31.4	20.9	48.0
60	15.9	67.4	48.8	27.9	15.0	45.3
63	13.0	64.0	44.8	25.3	15.0	42.3
66	9.3	61.9	31.8	18.1	6.4	36.0
69	9.3	53.7	31.0	16.8	6.5	32.3
72	8.9	....	....	....	....	....
75	8.9	....	....	....	....	....
78	8.4	....	....	....	....	....
81	8.4	27.3	14.2	.66	....	15.2

*This Grade includes 30 percent by volume of 6- and 7-foot lengths.

should be considered as the upper cutting length limit for No. 1 Common for this particular material bill. If the material bill should call for 27 percent or more of net footage in cuttings above the 54″ length, there might be a possibility that the No. 1 Common grade would not supply needs without excessive waste.

Similarly, in the No. 2 Common grade yield well exceeds needs up to the 45″ cutting class, and if the material bill should call for 27 percent or more of net footage in cuttings above this length, it would be difficult to supply the needs.

The line showing average yield for all grades lies well above the requirement line throughout the range. For this reason an assumption

could be made that the average grades used or the Selects would be satisfactory for the cutting bill. This however, is not always the most economical procedure as can be illustrated by the following example:

A sideboard requires 1,264 net feet of lumber in cuttings 81" in length, or 5.0 percent of the total requirement for 8 4 walnut in 1951. By referring to Fig. 2, it will be found that with the average grade used and the Selects grade, approximately 15 percent of the total yearly yield of cuttings will be long enough to supply the required material. Five percent is one-third of 15 percent so it would be necessary to comb through one-third of all the lumber used during the year to get the long pieces needed for the sideboard. The total amount of 8/4 walnut of all lengths needed for the sideboard is 2,755 net feet, or 10.8 percent of the total yearly requirement. Of the 64,695 board feet of 8/4 walnut used to obtain required cuttings in 1951, approximately 21,500 board feet must have been processed to make the sideboard, 7,000 of which went into the sideboard and 14,500 board feet into the cut-back pile, to be reprocessed.

If the lumber had been sorted so that only Firsts and Seconds had been used, 27.3 percent of the yield, or 6,949 feet, might be expected to fall in the 81" class. The sideboard requirement of 1,264 net feet is only 18.2 percent of the total yield in the 81" length class. Therefore, only 18.2 percent of the yearly 8 4 walnut requirement would have to be processed in the F. A. S. grade as compared with 33 percent in the selects, or the grade now in use. Further advantage could be derived from the fact that cutbacks would be longer than those obtained from the lower grades, thus reducing requirements for long cuttings from such grades.

The requirement curve, Fig. 2, shows that only 30 percent of the total net cutting footage is above 36" long. The remaining 70 percent is below 36" in length and very evidently can be obtained from any grades studied. From this it is apparent that possibly a combination of grades can be used; higher grades only for furniture pieces demanding long cuttings, and lower grades for those requiring short cuttings. This can only be determined from a study of comparative costs.

COMPARATIVE COSTS

To compare costs of cuttings from the different grades it is necessary to convert all costs to a 1000 net board-footage basis. This can most easily be done in the manner shown in Tables 8 and 9. Table 8 shows

the derivation *by grades* of the use percent, which is the percentage of the total lumber footage processed that can be converted into cuttings demanded by the material bill. The use percentage subtracted from 100 constitutes the total waste percent.

This waste percentage is not the same as the Table 7 residue percentage. Obviously it is not possible to get a 100 percent yield in net footage even from the most perfect boards. There will be some of the good, clear lumber that will not be usable because required sizes do not fit into it perfectly. This residue from the clear wood is what is shown in Table 7. Within any grade it is variable, depending on the sizes that must be cut and how the required sizes fit into the cutting sizes characteristic of the grade. For purposes of this study, residue percent was estimated as shown in Table 7.

RECOMMENDATIONS

Column 9, Table 8, shows cost per thousand net board-footage for 1951, for the different grades. These costs, however, can be attained only if the grades are used only to get the cutting sizes which naturally fall into that grade. A study of the cutting requirement (Table 6 or Fig. 2) shows that 26.5 percent of the year's consumption was in the 57″ class or over, whereas 70.8 percent was in the 36″ class or under, leaving only 2.7 percent in the classes between. Fig. 2 shows that the 70.8 percent can be easily obtained from the No. 2 Common grade. Column 9, Table 8 indicates that as long as the demand can be fully satisfied, No. 2 Common is the most economical grade to purchase. Hence, approximately 70 percent of the year's needs can be met most economically by No. 2 Common lumber. Previous discussion under Grade Yield indicated that the F. A. S. grade would be the most economical for the longer cuttings, to obtain lower costs. It is of prime importance that the F. A. S. grade be used only for the long cuttings. Purchase by separate grades, even at a higher price, is therefore necessary. These grades must be kept separate, for if mixed the pile must be combed to find long lengths, with resulting excessive waste and higher costs.

It is interesting to note from Table 8 that the No. 1 Common and Select grades, which are most commonly in demand, are the least economical for this particular cutting bill.

TABLE 7—Net yield and use percent for 8/4 walnut grades

Grade	Footage graded	Total yield clear cuttings	Percent yield clear cuttings $\frac{\text{Col. 3}}{\text{Col. 2}} \times 100$	Base footage	Footage less 5% shrinkage	Yield clear cuttings Col. 6 x Col. 4	Estimated residue percent	Yield net footage Col. 7 − Col. 8	*Use percent $\frac{\text{Col. 9}}{1000} \times 100$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
F. A. S.....	1,076	872.9	81.1	1,000	950	770.5	25	577.9	57.8
Selects.....	494	362.7	73.4	1,000	950	697.3	25	523.0	52.3
No. 1 Com...	1,508	1,012.5	67.1	1,000	950	637.5	30	446.3	44.6
No. 2 Com...	218	110.3	50.5	1,000	950	479.8	30	335.9	33.6

*Actual 1951 Use percent $= \frac{\text{Lumber footage}}{\text{Net footage}} \times 100 = \frac{64{,}695}{25{,}648} \times 100 =$ 39.7

TABLE 8—Net costs for 8/4 walnut grades

Grade	Use % from Column 10 Table 8	Material cost /M purchase price	Mat'l cost per M net footage Col. 3 / Use % x 100	Freight cost per M @ $30.00 30.00 / Use % x 100	Kiln drying* cost @ $40.20 per M. 40.20 / Use % x 100	Direct labor* @ $41.34 /M 41.34 / Use % x 100	Factory burden* @ 150% of direct labor	Total cost per M. net footage
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
F.A.S.	57.8	$370.00	$640.25	$51.90	$69.55	$71.52	$107.28	$940.50
Selects	52.3	330.00	630.98	57.36	76.86	79.04	118.56	953.80
No. 1 Com.	44.6	220.00	492.94	67.26	90.13	92.68	139.02	882.03
No. 2 Com.	33.6	100.00	297.71	89.29	119.64	123.04	184.56	814.24
Actual 1951 cost	39.7	$300.00	$755.66	$75.57	$101.26	$104.14	$156.21	$1,193.84

*Drying, labor, and burden costs given are for illustrative purposes only and are not actual costs.

RESULTS AND CONCLUSIONS

Results of the yield study at the Baker Furniture Company are as follows:

1. The use percentage for 1951 and that which might be expected from each grade under present operating methods was determined as indicated in Tables 7 and 8.

2. The cost to produce required cuttings from each of the grades under present operating conditions was determined. This cost is given as the cost per thousand board feet, net footage, and is tabulated with use percentage in Table 9.

TABLE 9—Use percent and net footage cost by grades

Grade	Use percent	Cost/M net footage
F. A. S.	57.8	$ 940.50
Selects	52.3	953.80
No. 1 Com.	44.6	882.03
No. 2 Com.	33.6	814.24
Actual 1951	39.7	1,193.84

3. The possible yield in different cut stock sizes was determined for each grade and compared with the yearly requirements. This is summarized in Fig. 2.

Savings could be effected in two ways: A. Fig. 2 indicates that the logical grades to purchase for the 8/4 walnut requirement would be F. A. S. and No. 2 Common in a proportion of approximately 30 to 70. Because of manufacturing problems, this may not work out immediately, so the original purchase under the plan should be in the proportion of 50 to 50. A reserve of F. A. S. should be maintained at all times and succeeding purchases should be in a proportion of F. A. S. only sufficient to maintain this reserve. Net footage costs per thousand under different grade ratios follow. Obviously, the less F. A. S. that is used, the greater the economy that will result.

B. The use percentage could be increased by a change in method of operation. This can be done by lowering the residue percentage (Column 8, Table 7) for any grade by giving the cutoff saw operator a greater variety of lengths to produce at one time and stock-piling extra lengths until needed.

TABLE 10—Footage costs for grade combinations

Percent by grade		Cost/M* net footage
F. A. S.	No. 2 Com.	
50	50	877.37
45	55	871.06
40	60	864.74
35	65	858.44
30	70	852.12

*In order to achieve these costs, the F.A.S. grade must be held back to produce cuttings 48″ and longer only.

The method followed in this study may be used by any woodworking plant to correlate cut stock requirements with grade yield. However, when a high percentage of wide widths are required, certain modifications of the method are necessary.

VERTICILLIUM WILT OF RASPBERRIES[1]

By ROBERT H. FULTON
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IN THE PAST 10 YEARS the acreage of bramble fruits throughout Michigan, especially in the southwestern section of the state, has steadily increased. A corresponding increase in bramble plant losses, in part due to a vascular wilt, has also been noted. Isolations indicated that this vascular wilt disease was frequently associated with the fungus *Verticillium albo-atrum* Rke. & Bert. (23).

The writer, in his investigations, has found two factors mainly responsible for those losses. The first is the high degree of susceptibility of the commercial raspberry varieties now being grown in Michigan. The other is that on all the farms visited in this investigation there was a history of crop rotations using potatoes, tomatoes, or eggplant at some time prior to the planting of raspberries. Those crops are well noted for increasing the Verticillium content of less contaminated soils.

From this study it was hoped that an accurate description of the symptoms of Verticillium wilt of black and red raspberries could be interpreted for growers, county agricultural agents and state inspectors. It was also desired that some feasible means of control be established.

REVIEW OF LITERATURE

The earliest recorded plant species associated with a wilt disease caused by *Verticillium* is the potato (*Solanum tuberosum*). In 1879, two German investigators, Reinke and Berthold (23), isolated a fungus from a potato plant affected with a disease called "Krauselkrankheit." They named the causal organism *Verticillium albo-atrum*.

The earliest record of *Verticillium* attacking any species of the genus *Rubus* was in 1904. Lawrence (16), in the Puget Sound area of

[1]Part of a thesis submitted in partial fulfillment of requirements for the degree of Master of Science, Michigan State College, 1951. The writer wishes to express his sincerest appreciation to Prof. Donald Cation for his constant inspiration and suggestions during the investigations and assistance in preparation of the manuscript.

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western Washington, described this fungus as the causal organism of "black raspberry *(Rubus occidentalis)* bluestem."

In 1923, *Verticillium* was reported on red raspberry *(Rubus idaeus)* in England by Harris (11). He called the disease "blue stripe"—a better term than "bluestem" (16) because most commercial varieties of red raspberry have a general bluish coloration normally on the new canes near the end of the growing season. This maturing coloration is also present on the new canes of black raspberries. The term "blue stripe" has not been adopted by plant pathologists in North America. They reject the term because black raspberries can be infected with a virus disease, "eastern bluestem" (29), that shows occasional symptoms of pencil-like blue streaks on the new canes. The disease caused by *Verticillium* has therefore been called "western bluestem," to differentiate between the two.

In 1926, Berkley and Jackson (2) reported a new species of the organism, which they called *Verticillium ovatum,* parasitic on five North American red raspberry varieties *(Rubus strigosus)* growing in New York and the Niagara-Ontario district of Canada.

In 1931, Rudolph (25) published a monograph on *Verticillium albo-atrum.* His studies on *Rubus* included methods of inoculation and the host range of *Verticillium* isolated from raspberry.

In 1936, Zeller (34) presented data of 8 years' research on Verticillium wilt of bramble fruits including symptoms, varietal resistance, field spread, and crop rotation studies.

Recent investigations on the Verticillium wilt problem in *Rubus* have been carried on by Wilhelm (30, 31 and 32). His studies included the vertical distribution of *Verticillium* in soils, varietal resistance studies on both raspberries and black berries, and types of crops in relation to the infestation of land with the wilt organism *Verticillium.*

CAUSAL ORGANISM

Such fungi as Verticillia are composed of complex mixtures of established biotypes, and repeated isolations from this complex will result simply in separating from the mass either single biotypes or new combinations of them. Presley (22) reported saltants from monosporic cultures of *Verticillium albo-atrum.* By repeated transfers from a monoconidial culture the writer has been able to isolate similarly four main biotypes of the Verticillium fungus, which are:

1. Microsclerotial dominant, slight mycelium.
2. Fluffy aerial mycelium.

3. Appressed mycelium.
4. Microsclerotial, abundant aerial mycelium.

Further transferring from biotype-4 soon sectors this isolate into any one of the other three biotypes. The biotypes 1, 2, and 3 have

S_1 S_2 S_3

Fig. 1. The biotypes S_1, S_2 and S_3 of *Verticillium albo-atrum*.

remained constant in transferring over a 10-month period. Throughout this study these three constant biotypes will be referred to as S_1, S_2 and S_3 (Fig. 1).

Prolonged cultivation in the laboratory induces in many species of the Fungi Imperfecti an abrupt change in type of growth. This has been reported by many investigators on the genus *Verticillium* (9, 21, 22, and 25). Hansen and Smith (9) suggested that the basic unit of the individual is the nucleus and not the cell. Therefore, a multinucleate conidium as has been noted in *Verticillium* (9), is not an individual but a colony, and it will not give rise to a genetically pure culture unless all of its nuclei are genetically identical. From this it may be hypothecated that the variable forms of *Verticillium* may owe their instability not to mutation but to nuclear heterogeneity (heterocaryosis).

It is widely known that the classification of the genus *Verticillium* cannot be established on the basis of gross cultural characteristics on standard media. Since gross morphological characteristics cannot be used as a means of separation among *Verticillium* isolates from different species of plants, another means of classification must be found. The host-pathogen relationship can be used to distinguish among species, as is found in the classification of the vascular group of the genus *Fusarium* (28). This would be of more value in the case of identification of this pathogenic fungus since no pronounced cultural or physiological differences have been reported by other investigators or noted in this study. The *Verticillium* pathogen isolated from raspberry in this study has a limited host range confined to the genus *Rubus* and a few species of solanaceous plants.

Another factor that could be used to further classify this fungus pathogen is the host-temperature relationship. Bennet (1) and Zeller (34) have reported that generally the most severe outbreaks of the wilt disease on raspberries occur in cool wet seasons and are correlated with the minimum temperatures and the number of days of below-freezing temperatures occurring in any particular winter. This is at variance with the results obtained in this study, for both laboratory and field data indicate that the most severe symptoms of Verticillium wilt on raspberry, induced by inoculations with the writer's *Verticillium* isolate, occurred during periods of high mean daily temperatures. Therefore, it is possible that the isolate used in this study differs in temperature requirements from those used by Bennet and Zeller and,

thus, temperature differences may possibly be used in the classification of the genus *Verticillium*.

Since the morphological observations in this study concur with those of Reinke and Berthold and the isolates were not specific to certain plant species as reported in *Verticillium dahleae* Kleb., it seems advisable to name the casual organism in this study *Verticillium albo-atrum* Rke. and Bert. (23).

METHODS OF INOCULATION

The *Verticillium* fungus is soil-borne (31) and can penetrate the roots directly (20). However, a variation of three plant inoculation methods were studied. The methods used are outlined below. For each series of inoculations comparable check inoculations were made, using sterile distilled water. The fungus was later reisolated in pure culture from each plant to prove the actual pathogenicity of the fungus according to the principles of Koch's postulates (15).

Method 1: The entire root system was simply dipped into a microsclerotial or conidial suspension and the plant potted immediately. An average of 36 days elapsed before visual wilt symptoms were evident in using this method. Biotypes S_1 and S_2 seemed to have the most pathogenicity as indicated by their shorter incubation period.

Method 2: The plant was potted and inoculated after it had become established. For inoculation a 6-inch iron rod was pushed into the soil manually near the base of the growing raspberry plant, making three or four such holes around the plant. The fungal suspension was then poured into each hole and the top of the hole covered with soil. When this method was used, the incubation period was shortened to 32 days, probably due to the actual wounding of the roots by the soil punch.

Method 3: The raspberry plants were potted and allowed to become established before being inoculated. With a flame-sterilized scalpel, a T-shaped incision was made into a cane to a depth of about ⅛ inch. Into this incision was placed a cotton wad previously soaked in a conidial or microsclerotial suspension of the causal organism. The treated incision was then covered with a proprietary self-sticking latex tape called Sealtex[2]. This tape not only sticks to itself but also seals against air and water loss from the covered area.

[2]Manufactured by the Sealtex Co., Chicago, Ill.

The cane wound method exhibited the shortest incubation period of the three biotypes used for inoculation. Therefore, as a result of these tests, the cane wound method was used throughout this study.

SYMPTOMS OF THE DISEASE

BLACK RASPBERRIES

The following symptoms are described from the Cumberland variety, but the symptoms on the other varieties of black raspberry were generally similar.

1. General Symptoms—The earliest signs of this disease on the black raspberry variety Cumberland are noticed on the current year's growth in late June or early July. The first symptoms seen are a dull green cast of the lower leaves when compared with the bright normal green color found on leaves of healthy shoots.

The entire stool may be affected, but more often the disease is confined to a few of the young shoots. Then too, this disease works rather slowly and usually from 1 to 3 years are required to kill a plant. The disease progresses upward, contrary to the observations of Czarnecki (6) and Lawrence (16) who reported that defoliation took place from the top of the plant downward. The symptoms of the disease are yellowing of the first leaves and stunting of growth caused by the shortening of the internodes, and finally the entire cane becomes wilted and the affected shoots usually develop a dark blue color, entirely or limited to stripes.

In the advanced stages of wilt the vascular tissue is discolored and has a water-soaked appearance. There is a definite line of demarcation between the vascular tissue and pith, the former being brownish and the latter usually a normal white. In severe cases the pith may be slightly brownish.

2. Leaf Symptoms—The amount of leaves which will show symptoms will depend entirely upon the amount of root infection. If the entire root system is infected the whole plant shows visible wilt symptoms. However, if only part of the root system is infected only that side of the plant above the crown in line with the infected roots will show visible signs of infection in the leaves. Generally, the lower leaves are the first to show signs of the disease (Fig. 2). The upper surface of the leaves develops an "off-green" or yellowish bronze cast which may be manifested by yellow and green, or brown and green

stripes. These stripes are separated by the lateral veins present on the leaves.

Fig. 2. (Right) Verticillium-infected black raspberry. (Left) Healthy plant.

The pattern on the black raspberry leaf extends from the midrib of the leaflet to its margin in a diagonal fashion following the lateral veins. The striping may be confined to one-half of the leaflet; but it

may and does affect other leaflets of the compound leaf. Coinciding with the striped pattern symptom, the leaflets occasionally tend to curl upward (noted in both black and red raspberry varieties) thus exposing the silvery underside of the leaflet (Fig. 3).

A compound leaf may have one-half of the terminal leaflet and the lateral leaflet on the corresponding side affected with this striped pattern while the other half appears normal. There are many possible combinations of the striped pattern effect. This observation corroborates the hypothesis of others that the effects of *Verticillium* diseases are concerned with the vascular system.

Following the beginning "off-green" color there is generally a marginal chlorosis, the leaflets turning from a yellow-green to a chocolate brown. This type of tissue discoloration may be erratically distributed throughout a single leaflet or envelope the entire compound leaf. The progressive pattern of necrotic areas is generally similar in all instances, beginning with a marginal and tip chlorosis of the leaf-

Fig. 3. Upward curling of leaflet margins on the red raspberry variety Indian Summer, following inoculations with Verticillium.

lets, soon followed by complete necrosis of the affected leaflet. It was also noted that when marginal necrosis occurred the entire leaf had a tendency to curl downward and resist pressing into a flat, normal plane of position. Nelson (20) in his studies of *Verticillium* on mint reported similar curling of the leaves.

Leaflets additionally infected with one of the leaf spot fungi *(Septoria rubi)* or *(Gleosporium veneta)* tend to wither and die with more rapidity than noninfected leaflets. The lesions tend to act as focal points for the spread of the necrosis.

The petioles may or may not show the blue discoloration characteristic of an affected cane. However, a pinching of the base of the petioles prior to actual leaf symptoms has been observed frequently.

3. Primo Cane (current year's growth) Symptoms—A discoloration of the primo cane will occur generally at the same time or earlier than the leaf symptoms. This cane symptom may begin at the groundline if only one or more laterals of the primary roots are infected. The symptom may begin several inches above the groundline if the infection is confined to the small secondary roots. If this latter type of infection occurs the entire crown may be destroyed in one growing season. If the causal organism does not attack the secondary lateral roots, the crown is not totally destroyed and will produce small shoots from the adventitious buds. These small shoots will generally become infected before the growing season is over, and they may defoliate from the base up or die back from the tip.

The intensely blue to purple discoloration extends in varying heights at variable rates in the black raspberry primo canes. These rates, which vary from zero to 9 inches a day, according to Lawrence (16), depend upon the environmental factors of temperature and moisture. A high mean temperature and low soil moisture content generally are conducive to higher daily spread of cane discoloration. The rate of climb is much slower in the fruiting wood than in the primo canes, and this may be correlated with the lower transpiration rate in the former. The discoloration generally forms a longitudinal stripe that touches every node along that side of the cane contiguous to infected roots. Occasionally, the blue stripe symptom advances into the petioles in varying degrees. The discolored stripe gradually narrows and terminates to a point.

The bluish discoloration noted on the primo canes is not due to a pigment produced by the fungus or the host but is the result of the

brownish-blue discoloration of the diseased bark as seen through the waxy bloom covering the cane. When the bloom is rubbed off, the purple color disappears (16, 25, and writer's observations).

The boundary between the normal and discolored portions, while rather irregular, is quite distinct. Discoloration in the cane may extend all around the cane. When two inches of a cane become encircled, the entire cane above the encirclement will wilt and die.

In the fall it is necessary to distinguish between the blue stripe symptom and the maturing color of the cane. As previously noted, blue discoloration appears on the cane near the groundline and is continuous in its pattern upwards, whereas change of color due to maturity often takes place irregularly in patches. This also holds true for red raspberry varieties.

Generally, the infected growth of the current season often appears healthy if the season has been moderate. However, the following spring one finds most of these canes dead at the tips and for varying lengths down the cane and to the base. New growth is usually noted at the base of these dead canes and the shoots appear healthy, though dwarfed or stunted.

4. Fruiting Cane Symptoms—The effects of the disease are finally climaxed in the fruiting canes. In the spring, the diseased canes are conspicuous. Some canes are dead, others have shrivelled and poorly developed buds. On some canes the dead buds lie in a longitudinal line. On sectioning such a cane, a strip of dead wood was found beneath the dead line of buds while the opposite side of the cane was green. The buds on the green side develop normally at first but later there is a stunting in both lateral shoot growth and leaves.

The wilting symptoms vary in their time of appearance on the fruiting cane. In some experimental plots the symptoms did not appear until the fruit was almost mature. On these canes the leaves become prematurely discolored and die, followed by a drying up of the fruit and death of the cane. In other instances, as soon as the first leaves had unfolded they became yellow and withered with no production of flower buds.

Wilhelm (30) observed that brambles are most seriously affected in the first and second fruiting years. If the fruiting canes are not dead before maturity they will usually yield small, tasteless fruit.

RED RASPBERRIES

The following symptoms are described from the Latham variety, but the symptoms on the other varieties of red raspberry are generally similar and in some instances were more severe (St. Regis and Indian Summer varieties).

1. General Symptoms—The red raspberry varieties have many symptoms of wilt that are identical with those symptoms found on the black raspberry varieties. The initial symptom is generally noticed on the current year's growth in the later part of July or early August. The lower leaves begin to change from a rich green to a light green color with a yellowish margin. Within a period of 14 days the leaves begin to fall off. A distinguishing characteristic is that the terminal tuft of leaves is invariably the last to be affected. These terminal leaves often survive the rest of the leaves for a considerable period of time.

The primo cane discoloration found quite prominent in black raspberries is often absent on red raspberry varieties, or if present, it is hard to distinguish from the normal bronze to reddish coloration. The fruiting wood generally has a deep brown to blue normal mature color that would mask any striping effect resulting from a *Verticillium* infection. In the red raspberry varieties a moderate infection of *Verticillium* may be present for years without depriving the plantation of its commercial value. This is not the case in the black raspberry varieties.

2. Leaf Symptoms—The striped pattern effect as noted on black raspberry leaves is more noticeable on red raspberry leaves because of the more prominent interveinal areas. This pattern has been well described previously.

It may be necessary occasionally to distinguish the defoliation of the Verticillium wilt disease from Spur Blight caused by *Didymella applanata*. In both instances the dead leaflets fall, leaving the petioles attached. The petiole may persist on the cane for 3 or more weeks.

In the case of the Spur Blight disease, a chocolate brown to darkened blue discoloration develops around the base of the petioles on the new canes. Pycnidia of the Spur Blight fungus can be observed with the aid of a hand lens in these discolored areas. In the case of *Verticillium* the discoloration generally appears in stripes and no fructifications of the fungus can be observed.

The symptom of the entire compound leaf curling downward as in the raspberry virus leaf curl (1) was noted occasionally on black raspberries. However, with all the red raspberry varieties tested, there was a pronounced downward curling of the terminal leaflet prior to actual color change in the leaflets. The downward curling of the terminal leaflet was also observed in the laboratory on tip cuttings of red raspberries placed in a filtrate of the toxin produced by the *Verticillium* fungus.

3. Root Symptoms—In the red raspberry varieties, as in the black raspberry, the infected vessels of the xylem are usually discolored. In severe cases most of the woody tissue in the roots have a pronounced brownish-red to black discoloration. The black raspberries do not reproduce by rhizomes; consequently, a diseased plant is more likely to die faster than those plants of the red raspberry varieties. In these observations, the rhizomes frequently were free of the causal organism. However, as the disease spreads in the roots these disease-free rhizomes eventually were attacked. It was also observed in confirmation of reports by Harris (11) and Rudolph (25) that red raspberry varieties infected with *Verticillium* do not sucker so plentifully as those free from this organism.

Three red raspberry plants of the Indian Summer variety showing visual wilt symptoms were tagged in comparison with three plants that appeared normal in growth. Counts were made in the late fall of that growing season on the number of suckers produced by the parent plants. The entire plants were then carefully dug up, keeping the root-sucker systems intact. Agar plantings were then made from the rhizomes of all six parent plants at the points of sucker attachment and also from the individual sucker plants. The results from this experiment are recorded in Table 1.

TABLE 1—Reduction of suckering following Verticillium infection of red raspberry

Parent plants	Number	Suckers, present number	Organisms isolated	
			Verticillia, number	Others, number
Infected	3	23	14	9
Normal	3	35	4	31

From Table 1 it is concluded: 1) Suckers from infected parent plants may be entirely free of the causal organism; 2) when red raspberries are infected with *Verticillium* the amount of suckering is reduced.

It will be noted from Table 1 that sucker plants from apparently healthy parents had become infected. This possibly resulted from natural infections from organisms in the soil.

This table suggests a point of interest in regard to field spread of the wilt disease organism. Sucker plants from infected parents can disseminate the fungus over the extent of their radius. The infected sucker plants growing in the aisles may be torn out of the ground by cultivating tools and dragged for some distance which may further spread the causal organism.

CONTROL MEASURES

After a complete review of the literature on the Verticillium wilt problem in raspberries, it appears that the control consists mainly in prevention of infection in the future planting rather than effecting a cure in an established plantation.

The fungus is believed to thrive in the soil as a saprophyte on the remains of plant parts. This fact was substantiated by the following test. Small pieces of leaves and canes of seven varieties of black and red raspberries were sterilized in propylene oxide vapor (10), then mixed with 2 percent sterilized agar and plated. The three biotypes S_1, S_2, and S_3 were seeded, with four replications, to each variety of the raspberry incorporated in the media.

At the end of 25 days the relative amount of fungal development was used as a criterion of the suitability of each substrate as a growth medium. No significant differences were noted either between biotypes or substrate of medium. This indicates that the causal organism can live saprophytically on the debris of these common varieties of raspberry.

McKay (18) and Zeller (34) reported the crop rotation studies of *Verticillium albo-atrum*. Their trials indicated that a 3- or 4-year rotation with two to three non-susceptible intervening crops, mostly grains, was effective in greatly eliminating the fungus from the soil.

Miles and Persons (19) reported that the heavier sedimentary and alluvial soils were more favorable to the disease than the sandy soils. Bewley (3 and 4), Leyendecker (17), and Sherbakoff (26) support the

same view that the heavier soils are favorable to the spread and propagation of the fungus. A possible reason for the greater prevalence of *Verticillium* in heavier soils is that they are better supplied with plant nutrients and humus to nourish saprophytic fungi, and are neutral to alkaline in nature which is a requirement for best Verticillium growth.

Apart from utilization of genetic resistance most of the recent investigations on *Verticillium* control have been directed at the soil. Keyworth (14) has recommended removal of the soil from an infected area to a depth of 3 feet. Wilhelm (31) found that on the whole the zero to 12-inch depths of the soil contained three to four times more infestation than the lower depths. Information on the depth of fungus penetration is essential before efficient use can be made of soil fumigants.

Richardson (24) tested many fungicides against *Verticillium albo-atrum* and the best results were obtained with mercuric chloride as a soil drench. This did retard the disease development but did not completely prevent it and was not commercially feasible. Garrett (8) and Keyworth (14) working with Hops, reported the use of 2-percent formalin as an eradicant for small outbreaks of the disease in a plantation. Young (33) noted that soil fumigation with chloropicrin or carbon bisulfide delayed the development of the disease and reduced the percentage of wilted plants. Smith (27) greatly reduced cotton wilt using ethylene dibromide. However, he also reduced the nematode population with this chemical which may be a contributing factor to the incidence of the wilt disease.

Another means of control may possibly be that of host nutrition. Gallegly (7) using sand-drip culture technique reported that an increase of nitrogen, potash, phosphorus also increased the disease and in unbalanced solutions only the low nitrogen decreased the incidence of disease. Nelson (20) noted that increasing the nitrogen improved the growth of mint with no increase in wilt.

Varietal resistance studies were used to determine whether any of the common varieties were possibly immune to attack by the *Verticillium* organism. The varieties tested were Latham, Indian Summer, Chief, St. Regis and Cuthbert red raspberries and the Cumberland and Morrison black raspberries. All these varieties were susceptible to the isolates of *Verticillium albo-atrum*. However, the incubation period for the symptoms was the longest with the Latham red raspberry variety.

Raspberries are a marginal economic crop because yields are not commensurate with prices received and the costs incurred with growing the crop.

Low yields are frequently traced to disease and insects, and certainly the *Verticillium*, if present, contributes additionally to low yields—in fact, it can be the contributing factor to practically a complete crop loss. As costs are already high, soil disinfection is impracticable unless it can be shown that yields are materially increased or if by there use on a small area, the disease can be eliminated or restricted. Further exploration of economically feasible soil treatments are needed.

It has been definitely shown in these studies and elsewhere that the strains of *Verticillium* attacking *solanaceous* crops are also pathogenic to raspberry. Therefore, the one precaution that is definitely indicated is to avoid preceding raspberries with solanaceous crops. This precaution is not well understood by growers and seems to be the principal source of infection in Berrien County.

The symptoms of the disease are obscure and confused with soil deficiencies. To what extent the disease is spread by nursery stock is not clear. However, Bennett (1) indicated that nursery stock was responsible in many cases for he traced infections to new plantings not preceded by tomatoes or potatoes. This needs additional study but is certainly worth every precaution by growers to avoid propagation from possibly infected material.

Biological control by antagonistic cover crops have not been indicated for *Verticillium* on raspberry, but rotations using grasses have cleared the soil of the organism to allow further profitable potato production. This method is also indicated for raspberry as the same organism is involved.

SUMMARY

This paper reports the results of investigations on the fungus *Verticillium albo-atrum* Rke. and Bert. and its pathogenic relationship to black and red raspberries.

Three constant biotypes of the *Verticillium* fungus were isolated. They are S_1 (microsclerotia dominant), S_2 (fluffy mycelium), and S_3 (appressed mycelium). All three biotypes were pathogenic to raspberry with the S_1 and S_3 biotypes being the more potent.

The symptoms of the disease on black and red raspberries are fully described. The general symptoms of yellowing and drooping of the leaves progressing from the base upwards is characteristic of both species investigated.

Root studies on diseased red raspberry showed that some of the sucker plants may be entirely free of infection and the amount of suckering is reduced as a result of the disease.

Crop rotations of raspberry following solanaceous plants were conducive to the disease and should be avoided. No other practical control measures were indicated as far as studied.

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USE OF POLYETHYLENE FILM IN THE PROPAGATION AND CULTURE OF CERTAIN HORTICULTURAL PLANTS

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DURING THE LAST 5 years, the age-old practice of air-layering has received new impetus with the use of plastic films as a means of maintaining the moisture supply during the process of rooting.

A review of the pertinent literature appears in an article by Donald Wyman, of the Arnold Arboretum.[2] He reported on some 250 species of woody plants and showed a fair degree of success in establishing roots in air-layers using "polythene film" for moisture control.

An attempt was made by the author at East Lansing to root herbaceous cuttings, using polyethylene film in a similar wrap.

MATERIALS AND METHODS

After preliminary trials, materials were chosen and a method of procedure planned which seemed to fit the average herbaceous cutting. Materials used were:

Polyethylene squares, 7″ x 7″

Sphagnum moss, moist

Rubber bands, size No. 10

Cuttings of Chrysanthemum, Begonia, Fuchsia, Carnation, Poinsettia, Pelargonium, and Coleus.

RESULTS WITH CUTTINGS

A handful of moistened sphagnum moss was squeezed lightly to remove excess water and placed on the square of film (Fig. 1). Cuttings were made in the usual commercial manner, and the basal portion of each was nestled nearly to the bottom of the moss. The sides of the

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[2]Wyman, Donald (1952) Air Layering with Polythene Film. Roy. Hort. Soc. Jour. 77:135-140.

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polyethylene square were lifted and a rubber band placed around the top of the bag, thus formed. The packages were placed on screens over the propagation bench.

Fig. 1. Geranium cutting being placed in handful of moist sphagnum on a square of polyethylene.

Experiments with controlled temperature, light, air-circulation, and humidity showed the usual propagation house of high humidity and even temperature (70° F.) to be suitable for rooting of cuttings in polyethylene. No watering of the wrapped plants was necessary during the 2 to 3 weeks required for root formation. The time of rooting and the quality of the roots were observed easily by looking at the bottom of the polyethylene bags. The individually wrapped cuttings rooted in the same period or faster than did the bench cuttings made at the same time.

Disease was observed in only 3 plants out of 100 which were wrapped in polyethylene, whereas one entire bench (60) of unwrapped plants was destroyed by fungi during this period.

RESULTS WITH SEEDLING TRANSPLANTS

Further experiments were conducted to determine the feasibility of growing vegetables and flowers from seed for transplanting out-of-doors, using the polyethylene wrap. Common garden kinds were selected such as marigolds, petunias, tomatoes, and peppers. Seeds were planted in greenhouse flats of three separate materials, sphagnum moss, vermiculite, and muck. When the young seedlings were about 3 inches tall, they were packaged in squares of polyethylene as was done with cuttings described above. The rooting medium was treated with a 10-5-5 analysis liquid fertilizer at the rate of 5 cc. per plant.

Fig. 2. Preventing moisture loss in potted plants by use of a polyethylene wrapper.

The packaged seedlings were placed in a greenhouse bench under conditions favorable to good growth for a period of 3 weeks. At the end of the 3-week period, the plants were transplanted to the field.

The lightly formed ball of roots simplified the process of setting. No wilting occurred, and the plants started well in the field.

RESULTS WITH POLYETHYLENE FILM WITH POTTED PLANTS

Polyethylene squares were placed around 4- and 6-inch pots of Pelargoniums and Hydrangeas in an attempt to conserve moisture loss from greenhouse potting soil. After wrapping, the pots were placed in the living room of a house at room temperature (70° F.) and average humidity (40 percent).

Flowering Pelargonium and Hydrangea plants retained turgidity for a period of 3 weeks without watering before showing symptoms of moisture deficiency.

SUMMARY

Herbaceous cuttings were rooted successfully in a proper rooting medium wrapped in squares of polyethylene film, similar to that used in air-layering technique. No watering was necessary during the rooting period. Seedling plants grew to transplanting size in polyethylene wrappers with the addition of liquid fertilizer. Planting operations, in both cases, were simplified by the formation of a compact ball of undisturbed roots. Polyethylene film was used successfully to conserve moisture loss in potted plants.

JOURNAL ARTICLE ABSTRACTS

The Pantothenic Acid Content of Fresh and Stored Shell Eggs

Evans, Robert John; Davidson, J. A., and Butts, Helen A.

Poultry Sci. 33 (5): 777-780. 1952 (Journal Article 1203 from the Michigan Agricultural Experiment Station)

Eggs from White Leghorn hens kept in individual laying cages were assayed for pantothenic acid with *Lactobacillus arabinosus* after preliminary digestion with Mylase P. Fresh eggs and eggs from each hen stored at 0° C. for 3, 6, and 12 months were used. Fresh eggs contained on the average 608 μg. of pantothenic acid per egg or 12.5 μg. per gram. The highest concentration was in the yolk which contained 30.6 μg. per gram, compared with 3.0 μg. per gram in the albumen. The average amount of pantothenic acid per yolk of one egg was 511 μg. and per albumen 97.7 μg. An average loss of 49 μg. (8 percent) of pantothenic acid per egg occurred during 12 months of cold storage. There was also a transfer of pantothenic acid from the yolk to the albumen. Twelve-month-old eggs had on the average 347 μg. (17.8 μg. per gram) of pantothenic acid in the yolk and 213 μg. (7.8 μg. per gram) in the albumen.

Studies in Plant Carbonic Anhydrase. Part I. Occurrence, Distribution and Properties

Lucas, E. H., and Byerrum, R. U.

Papers Mich. Acad. Sci. Arts and Letters 37: 55-61. 1951 (Journal Article 1211 from the Michigan Agricultural Experiment Station)

The general occurrence in green tissues of phanerogams of an enzyme catalyzing the dehydration of carbonic acid is reported. The activity of this enzyme varies widely in the different plant species tested. The method by which this enzyme was identified, and several characteristics of the enzyme are discussed.

A Study of Bias in the Selection of a "Representative" Sample of Small Fish

Hayne, Don W.

Papers Mich. Acad. Sci. Arts and Letters 37: 133-141. 1951 (Journal Article 1235 from the Michigan Agricultural Experiment Station)

Field investigators sometimes must select a small sample from a larger one which cannot be preserved as a whole. Samples may occasionally be selected as "representative" rather than as random samples. In a laboratory experiment, each of eight investigators chose one sample from each of eight lots of small fish. These fish had been measured previously, and their average lengths could be compared with those of the samples. All of the investigators chose the larger fish in greater proportion. Bias was also related to the variability of the lots of fish. The conclusion is drawn that if samples are selected as "representative" then bias may well be present.

What Is a Reasonable Mold Count for Black Raspberries in the Great Lakes Region?

FABIAN, F. W.; BENEKE, E. S.; ERICKSON, F. J., AND FLOATE, RAY

The Canner 118: (18) 14-16; (19) 16-20; (20) 16-20. 1951 (Journal Article 1239 from the Michigan Agricultural Experiment Station)

The present work, done during the summer of 1950, was designed to make a thorough study of the molds occurring on black raspberries before they were picked, and at each of the various steps from the time they left the plants in the field until they had been processed as canned or frozen berries. This study included a) the stage of development of the berries at which the molds occurred, b) the effect of various field sprays, dips and flat treatments upon the presence and development of the molds, c) the influence of such factors as temperature, humidity and storage time upon the development of the molds under the conditions of commercial production, harvesting and manufacture, d) the kinds of molds found under these conditions and, finally, e) whether the evidence of mold on black raspberries was evidence of fruit decomposition or spoilage.

Immature berries contained few or no molds, while drupelets from ripe black raspberries usually contained molds. Berries harvested during warm, humid weather had higher mold counts than those harvested and processed under warm, dry conditions. The time interval between ripening and picking the berries was found to be an important factor in governing the mold count. Washing did not lower the mold count significantly, indicating that the molds were inside the drupelets.

The authors conclude that an alleged unofficial mold in 40 percent of the microscopic fields is not justified and that a reasonable standard for black raspberries produced in the Great Lakes region should be not over 76 percent of the microscopic fields for a single sample or not over 60 percent for an average of 10 samples.

Relation of Seed Germination to Soil Moisture Tension

HUNTER, J. R., AND ERICKSON, A. E.

Agronomy Jour. 44 (3): 107-109. 1952 (Journal Article 1242 from the Michigan Agricultural Experiment Station)

A study of the minimum seed and soil moisture requirements for germination of various seeds on different soils has shown a relationship between seed germination and moisture tension of soils. In order to germinate, each species of seed had to attain a specific moisture content. For the seeds tested this ranged from 26.5 percent for rice to 50.0 percent for soybeans. To attain those characteristic moisture contents, there is a maximum soil moisture tension which is specific for each species of seed but common to all the soils studied. These ranged from 3.5 atmospheres tension for sugar beets to 12.5 atmospheres tension for corn.

These relationships, coupled with the fact that seeds in a soil environment too dry for germination are soon attacked by fungi, partially explain the poor germination of sugar beets as compared with corn under field conditions.

A Study of the Response of Malting Barley Varieties to Different Fertilizer Analyses

FREY, K. J.; ROBERTSON, L. S.; COOK, R. L., AND DOWN, E. E.

Agron. Jour. 44: 179-182. 1952 (Journal Article 1244 from the Michigan Agricultural Experiment Station)

Several malting barley varieties were grown during the years 1947-1950 on soils to which different fertilizers had been applied. Grain and straw yields and test weights were recorded for each treatment. Significant fertilizer-by-variety interactions were found in 1947 and 1949 for grain yields. In 1947 the significant interaction for grain yield resulted when O. A. C. 21 did not respond to fertilizer treatment while Bay and Wisconsin 38 did. In 1949 the significant fertilizer-by-variety interaction was due to reduction in the yield of Moore variety when a complete fertilizer was applied.

None of the fertilizer-by-variety interactions for straw yield was significant. In two of the three years, the application of a complete fertilizer resulted in slight reduction in test weight.

On the basis of the literature, it is suggested that, in general, crops in which one variety has a small area of adaptation (such as corn) tend to show a significant variety by fertility level interaction, while those crops in which any one variety has a large area of production (such as oats) do not show significant variety-by-fertility level interactions.

Some Observations of the "Podzolized" Gray-Brown Podzolic Soils of Michigan

GARDNER, D. R., AND WHITESIDE, E. P.

Soil Sci. Proc. 16 (2): 137-141. 1952 (Journal Article 1257 from the Michigan Agricultural Experiment Station)

Studies were made of soil profiles from an area in central Michigan lying along the Podzol-Gray-Brown Podzolic region transition. The profiles are grouped in a lithosequence of seven textures from sand to silt loam and reproduced photographically. Selected physical and chemical analyses from three of the seven textures are presented tabularly.

Through the range of textures studied, these profiles possess a common sequence of horizons. While the surface horizons are clearly those of a Podzol, they are underlain by what appear to be the A_2 and B_2 of a Gray-Brown Podzolic profile. The influence of the texture of parent material is such that, in the sandier types, the upper Podzol is much more strongly developed than is the lower Gray-Brown Podzolic profile, while in the heavier textures, the reverse is true.

The authors conclude that these double profiles represent the zonal soil for this area and are correlatives of the double profiles described by other workers in New York and in Ontario. These soils are neither true Podzols nor true Gray-Brown Podzolic soils but exhibit the characteristics of both groups, the affinity for one or the other being related to texture.

The Measurement of Oxygen Diffusion in the Soil with a Platinum Microelectrode

LEMON, E. R., AND ERICKSON, A. E.

Soil Sci. Proc. 16 (2): 160-163. 1952 (Journal Article 1258 from the Michigan Agricultural Experiment Station)

The current obtained in the electrolysis of an electro-reducible material, as oxygen, at the surface of a platinum electrode can be used to calculate the rate of diffusion of that material.

Measurements made in the soil, *in situ*, based on this principle, gives promise of furnishing a new, simple, rapid and inexpensive method of determining the rate of oxygen supply to an undisturbed environment similar to that in the liquid film surrounding an actively respiring plant root.

Evidence has been presented, indicating that the factors controlling the diffusion rate in the gaseous phase of the soil extend into the liquid phase as well. What additional factors that are unique in their effects on oxygen diffusion in the liquid phase of the soil are at present little understood. There is evidence that at lower porosities moisture film thickness is of greater importance in controlling oxygen supply to the root surfaces than at higher porosities. Plant growth correlates well with oxygen diffusion measurements made with the platinum microelectrode.

Variations in the Protein and Amino Acid Contents of Different Oat Varieties

FREY, KENNETH J.

Cereal Chem. 29: 77-81. 1952 (Journal Article 1261 from the Michigan Agricultural Experiment Station)

The average protein content of the grain of 14 oat varieties was 25 percent higher in 1949 than in 1947. Although the contents of lysine, leucine, and methionine were 47, 47 and 43 percent higher, respectively, in 1949 than in 1947, the tryptophane content was only 12 percent higher. These data show that environmental variations associated with season and planting area tend to change proportions of certain amino acids in the oat protein. Such changes in the tryptophane component were not so apparent in Mindo and Andrew varieties as in Mohawk, Clinton, and Huron. The average percentages of tryptophane, lysine, leucine, and methionine in the oat protein were 1.2, 3.4, 7.0, and 1.2, respectively.

Aerobacter aerogenes as a Cause of Ropy Brine in Cucumber Fermentation

FABIAN, F. W., AND ALLEN, C. W.

Food Res. 16 (5): 446-447. 1951 (Journal Article 1262 from the Michigan Agricultural Experiment Station)

Ropy fermentation is encountered frequently in the food industry. The cause of ropiness has been found to be due to bacteria. The present study was conducted in August 1950 in vats of fermentating cucumbers in Michigan. Brine in some, but not all, of the vats at this salting station had turned ropy and was causing considerable anxiety to the salter. He had never encountered this particular condition before and wanted to know what caused it.

Samples of brine from the ropy vats were collected and a bacteriological examination made of them. The predominating organism was isolated and

identified as *Aerobacter aerogenes*. This particular organism has been shown to be the cause of ropiness in milk, tea, and maple syrup by other investigators.

Precooked Frozen Vegetables

PAUL, PAULINE C.; COLE, BETTY IVES, AND FRIEND, JEAN CARSTENSEN

Jour. Home Econ. 44 (3): 199-200. 1952 (Journal Article 1266 from the Michigan Agricultural Experiment Station)

Tests were made on the palatability and ascorbic acid content of precooked frozen asparagus, carrots, green beans, broccoli, and cauliflower. The results indicated that freezing these vegetables after complete cooking is not a desirable practice. When reheated for service, the products were partially disintegrated, flavorless or off-flavor, soggy, mushy, and fair to poor in color. The ascorbic acid content decreased materially over that of vegetables processed according to the usual blanching procedure.

Stages in Anatomical Development of the Flower Head of Chrysanthemum morifolium Bailey

ANDREWS, PAUL S., AND WATSON, DONALD P.

Proc. Am. Soc. Hort. Sci. 59: 516-522. 1952 (Journal Article 1283 from the Michigan Agricultural Experiment Station)

Four stages of buds developing flowers over a period of 36 short days are described in detail. These stages were found to develop three times as rapidly under greenhouse conditions where the temperature during the light period rose above 60° F. and the light intensity exceeded the 1,000 foot candles used in the experiment. The cellular arrangement in the vegetative shoot of the variety Gold Coast did not conform to the zonal regions described by Popham and Chan for the variety Bittersweet. Early flower bud initiation was observed to be in conjunction with a "mushrooming" or strongly arched effect in the apical meristem similar to that reported by Philipson in *Bellis perennis* and Popham and Chan in *Chrysanthemum morifolium*. The actual change from a vegetative to reproductive stage in the chrysanthemum apparently occurs rapidly because few of the buds sectioned were in the transitional stage. This is similar to the condition in the Gramineae. Many periclinal divisions observed in the upper corpus region immediately preceding the occurrence of the flower buds substantiate Philipson's belief that the primary change leading to flowering was an elongation of the cells immediately below the apical meristem.

Influence of Daylength and Temperature on the Growth of Greenhouse Violets

COOPER, CALVIN C., AND WATSON, DONALD P.

Proc. Am. Soc. Hort. Sci. 59: 549-553. 1952 (Journal Article 1284 from the Michigan Agricultural Experiment Station)

Commercial flower production will take place only under a short photoperiod. Ten weeks from the beginning of this photoperiod are required to produce saleable flowers when the plants are grown at 50° F. night temperature. The flowers are larger when they are grown at 50° than at 40° F. night temperature. It seems of little value to supply a long photoperiod to obtain vigorous growth since under

the shorter photoperiod, the long-day foliage type tends to dissipate. Furthermore, the production of the foliage type must precede the production of the flower type, characteristic of the day length period.

The Influence of Variations in Environmental Temperature and Thyroid Status on Sexual Function in Young Female Mice

SOLIMAN, FOUAD ATALLA, AND REINEKE, E. P.

Am. Jour. Phys. 168 (2): 400-405. 1952 (Journal Article 1288 from the Michigan Agricultural Experiment Station)

Groups of immature female albino mice were maintained at temperatures of 24°, 30° and 35° C. In addition, certain of the groups were given thiouracil or small amounts of thyroprotein incorporated in their ration. In mice kept at 24° C. ovary weights were increased significantly by 0.0125 percent thyroprotein but depressed by higher levels. At 30° and 35° C., 0.005 percent thyroprotein had no effect on the weight of the ovaries. However, thyroprotein at all temperatures and all levels employed caused significant increases above their controls in weight of the uterus.

Both thiouracil and thyroprotein administration resulted in earlier opening of the vagina. The thiouracil-fed mice showed continuous estrous, as judged by vaginal smears. Slightly hyperthyroid mice exhibited regular estrous cycles. Sexual maturation was accelerated at all levels of thyroprotein feeding as shown by the occurrence in these groups of corpora lutea and progestational changes in the uterus. The thiouracil groups had ovaries packed with follicles, but no corpora lutea, together with typical estrogen stimulation of the uterus.

The possible significance of the thyroid function in control of the estrous cycle is discussed.

A Study of the Pathology of the Intestine and Other Organs of Weanling Pigs When Fed a Ration of Natural Feedstuffs Low in Pantothenic Acid

SHARMA, G. L.; JOHNSTON, R. L.; LUECKE, R. W.; HOEFER, J. A.; GRAY, M. L., AND THORP, FRANK, JR.

Am. Jour. Vet. Res. 13 (48): 298-303. 1952 (Journal Article 1313 from the Michigan Agricultural Experiment Station)

Eight Duroc weanling pigs, kept on concrete floor, were fed a basal ration composed of corn, soybean oil meal and a mineral mixture. The ration contained 18 percent crude protein and 4.53 milligrams of pantothenic acid per pound of feed. The ration was supplemented with riboflavin, niacin, Merck's A.P.F., vitamin A and vitamin D. The same number of control pigs received the corn-soybean ration supplemented with pantothenic acid.

The pigs on the deficient ration developed anorexia and diarrhea two weeks after placing the animals on the ration. Average daily feed consumed by the deficient pigs was 1.52 pounds, whereas the control pigs consumed 1.99 pounds of feed per day. Average daily gain in weight of the pigs, on the deficient ration, was 0.31 pound; the control pigs made an average daily gain of 0.68 pound during a comparable period. The deficient pigs consumed 4.68 pounds of feed per pound of gain in weight, whereas the control pigs required 2.94 pounds of the ration for a similar gain.

The gross and microscopic alterations were mainly confined to the large intestine, although the posterior parts of the small intestine were occasionally involved.

There was marked congestion of the mucosa of the large intestine and sometimes ecchymotic hemorrhages were detected. In the later stages of the disease, the degenerating columnar epithelium had desquamted from the basement membrane. In some areas small superficial discrete ulcers were detected. The fecal material adhering to the mucous membrane could easily be washed away by a gentle stream of water.

Microscopic changes were characterized by hyperemia of the lamina propria and retrogressive changes of the columnar epithelium. Cellular infiltration into the lamina propria was mostly lymphocytic in nature although a few macrophages, plasma cells and polymorphonuclear leukocytes could also be seen. The exudate consisted mainly of mucus, cellular debris and degenerating leukocytes. The crypts of Lieberkuhn showed cystic dilatations, and the lymph nodules had undergone hyperplastic changes. One of the pigs, sacrificed on the 26th day, showed fibroblasts proliferating in the lamina propria.

Control pigs fed on the ration supplemented by pantothenic acid did not show the deficiency symptoms.

The Effect of Antibiotics on In Vitro Cellulose Digestion by Rumen Microorganisms

WASSERMAN, R. H.; DUNCAN, C. W.; CHURCHILL, E. S., AND HUFFMAN, C. F.

Jour. Dairy Sci. 35 (7): 571-580. 1952 (Journal Article 1317 from the Michigan Agricultural Experiment Station)

Incubation studies were made with artificial rumens to study the persistency and effect of penicillin, streptomycin, neomycin and chloromycetin on rumen microflora and to determine the influence of these antibiotics on *in vitro* cellulose digestion. Periodic antibiotic assays showed that the concentration of streptomycin increased above the initial level during the first 8 hours and persisted at a high level throughout the 24-hour period. Approximately 40 percent of the neomycin disappeared within 45 minutes and then the rate of disappearance was slow for the rest of the period. The concentration of penicillin dropped to less than 25 percent of the original value within 45 minutes and then persisted at a constant level for the rest of the period. The level of chloromycetin decreased rapidly and was not detectable after 4 hours. In the concentrations used, a) penicillin stimulated the cellulolytic rumen microorganisms at the lower concentrations, b) neomycin was stimulatory in all concentrations, c) streptomycin was slightly stimulatory in the lowest concentration and d) chloromycetin adversely affected the microorganisms.

Life History of the Stemphylium That Causes Red Leaf Spot of Gladiolus

NELSON, RAY, AND MOOAR, MARIE

Phytopathology 42 (34): 363-366. 1952 (Journal Article 1319 from the Michigan Agricultural Experiment Station)

Stemphylium has been isolated from gladiolus leaves from Michigan, California, Florida, New York and New Jersey. One New York isolate of September 16, 1946, on prune agar formed much larger stromata than other cultures and was subjected to varying environmental conditions, including freezing and drying.

April 21, 1948, 19 months after seeding with *Stemphylium* sp. the plate contained *Pleospora* perithecia and mature asci. Single-spore cultures were obtained from ascospores expelled to the cover of the Petri plate. Typical Stemphylium red leaf spot resulted from infection of gladiolus leaves with these cultures. Re-isolates from the lesions formed much larger stromata than previous cultures. The perithecia are globose, irregularly clustered, and densely setose. The outer cells are thickened and black. Perithecia are 396-555 × 460-904, average 495 × 725 microns. The asci are cylindrical, thin-walled with a thick, gelatinous inner wall. Ascospores are 11-30 × 29-70, average 17 × 42 microns, and vary from light, transparent yellow-brown to dark red-brown. The number of cross and vertical ascospore walls varies greatly within one perithecium. Species determination has been deferred.

The Effect of Terramycin on the Growth of Pigs Fed Different Levels of Protein

HOEFER, J. A.; LUECKE, R. W.; THORP, F., JR., AND JOHNSTON, R. L.

Jour. An. Sci. 11 (3): 455-458. 1952 (Journal Article 1327 from the Michigan Agricultural Experiment Station)

Eighty 25-pound pigs were used to study the effect of terramycin on the growth of pigs fed different levels of protein. Terramycin at 5 mg. per pound of total ration had a highly significant effect on rate of gain and also improved efficiency of gain. It did not seem to affect the requirement of the pigs for protein. The pigs receiving the 15-percent protein ration (reduced to 12 percent at 100 pounds) did just as well as the pigs receiving the 18-percent protein ration (reduced to 15 percent at 100 pounds). It is suggested that our present standards for protein for pigs may be higher than they need be, and that the high level of B vitamins used in this study may be related to an increased efficiency of protein utilization.

The Use of Dry Sugar, Sugar Sirup and Ascorbic Acid in Frozen Montmorency Cherries

LOUTFI, S. E.; BEDFORD, C. L., AND ROBERTSON, W. F.

Quick Frozen Foods 14 (12): 55-57. 1952 (Journal Article 1328 from the Michigan Agricultural Experiment Station)

Montmorency cherries frozen with ascorbic acid added at the rate of 150 to 175 mg. per 12 ounces of pitted fruit were found to retain their fresh fruit flavor and color. Syrup packs offered more protection than dry sugar and those with 60° Brix syrup density were better than the lower densities in preventing the development of off-flavor and browning.

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LAKE CITY EXPERIMENT STATION (Missaukee County)—Ashley Berridge, M. Agr., Superintendent